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## USSR AND EASTERN EUROPE SCIENTIFIC ABSTRACTS

### PHYSICS

No. 43

This serial publication contains abstracts of articles and news items from USSR and Eastern Europe scientific and technical journals on the specific subjects reflected in the table of contents.

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Crystals and Semiconductors

USSR

UDC 621.372.8:621.315.61:548.526

WAVEGUIDES FORMED BY DIFFUSION OF TITANIUM AT THE Y-CUT OF AN  $\text{LiNbO}_3$  CRYSTAL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 305-310  
manuscript received 16 Feb 77

PAN'KIN, V.G., PETUKHOVA, S.N., PCHELKIN, V.YU., SHASHKIN, V.V., and SHVARTS, N.L., Institute of Semiconductor Physics, Siberian Division of the USSR Academy of Sciences, Novosibirsk

[Abstract] Waveguides were produced by diffusion of titanium at the Y-cut of a  $\text{LiNbO}_3$  (lithium metaniobate) crystal in argon, nitrogen, air, or vacuum. The thickness of titanium films was measured either with an LEF-2 photoelectric ellipsometer (smaller than 80.0 nm) or with an MII-4 interferometer (larger than 80.0 nm). These test data were then used to calculate the depth profile of the refractive index for both ordinary and extraordinary rays, according to the Wentzel-Kramers-Brillouin method on the basis of the mode equation and a piecewise-linear approximation. The electro-optical conversion coefficient  $r_{33}$  for a TE-mode was also determined. The results indicate that a minimum amount of titanium, at least a 35.-45.0 nm thick film, is necessary for forming a waveguide. The optical losses due to scattering depend on the diffusion medium: only 2 dB/km or less in a 50 nm film diffused at 1000°C in argon or vacuum, but 7 and 20 dB/km in a 50 nm film diffused at 1000°C in air or nitrogen respectively. Figures 3; references 14: 5 Russian, 9 Western.

USSR

UDC 537.533

CONCERNING THE QUESTION OF FORMATION OF THE EMISSION EDGE OF A CATHODE FLARE PLASMA IN EXPLOSIVE EMISSION OF ELECTRONS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 47, No 10, Oct 77  
pp 2086-2091 manuscript received 7 Jul 76

BAZHENOV, G. P., LADYZHENSKIY, O. B., LITVINOV, YE. A. and CHESNOKOV, S. M., Institute of Optics of the Atmosphere, Siberian Department, Academy of Sciences USSR, Tomsk

[Abstract] Experiments are done on diodes operating in the explosive emission mode to check the hypothesis of a connection between the

instability of the explosive emission current and nonuniformity of the ejection of cathode material into the cathode flare plasma. Analysis of the dynamics of formation of the emission edge confirms this hypothesis. In the course of the saturation time  $t_s$ , the emitting surface of the cathode flare plasma propagates at a velocity  $V_e$  that is greater than the previously observed average velocity of expansion of the plasma  $V = 2 \cdot 10^6$  cm/s, which is due to the formation of a virtual cathode in front of the emission edge  $V_e$ , becomes less than  $V$ , which can be attributed to a transition to the saturation mode. Current takeoff in the saturation mode conforms to the 3/2 law. Excess of the current over the Langmuir limit in a flash is associated with the possibility of formation of "breaks" in the plasma at a point of localized reduction in plasma concentration. Figures 3, references 12: 11 Russian, 1 Polish.

USSR

UDC 533.537

# ON CALCULATING THE CHARACTERISTICS OF AN ELECTRON BEAM FORMED IN DIODES WITH MAGNETIC ISOLATION

Tomsk IZVESTIYA VUZov: FIZIKA in Russian No 10(185), 1977 pp 134-135  
manuscript received 1 Mar 77

FEDOSOV, A. I., LITVINOV, YE. A., BELOMYTTSEV, S. YA. and BUGAYEV, S. P.,  
Institute of Optics of the Atmosphere, Siberian Department, Academy of  
Sciences USSR

[Abstract] Previous research on electron beams generated in diodes with magnetic isolation has apparently demonstrated that the current of the beam produced in the diode is equal to the limiting current of the transporting system. In this paper it is shown for a specific system that the beam current may be determined by the zone of acceleration in the diode rather than by the throughput of the transporting system. The beam parameters must be found from the solution of the corresponding problem for equations that describe the electron flux with consideration of electrostatic and magnetic self-fields and boundary conditions. However, in the case of simple cylindrical geometry of the diode and an infinitely strong driving magnetic field, certain conclusions can be drawn on the beam characteristics in the drift space without finding the form of the solution in the acceleration space. Expressions are derived for the beam parameters that can be used to check the accuracy of computer calculations. Figure 1, references 5: 4 Russian, 1 Western.

## INVESTIGATION OF ELECTROPHYSICAL AND PHOTOELECTRIC PROPERTIES OF DIFFUSION LAYERS OF GALLIUM ARSENIDE MADE BY DOPING WITH COPPER

Tomsk IZVESTIYA VUZov: FIZIKA in Russian No 10(185), 1977 pp 95-100  
manuscript received 21 Feb 77

KRIVOV, M. A., MALISOVA, YE. V., MEL'CHENKO, E. N., NIKIFOROVA, M. P.,  
POPOVA, YE. A., TARASOVA, L. K. and KHLUDKOV, S. S., Siberian Physicotechni-  
cal Institute imeni V. D. Kuznetsov Affiliated with Tomsk State University

[Abstract] The authors study the distribution of electrophysical and photoelectric parameters of diffusion layers of p-GaAs produced by doping with copper under different thermodynamic conditions of diffusion. The initial materials were single crystals with electron concentration of  $(1-2) \cdot 10^{17}$  and  $(1-3) \cdot 10^{18} \text{ cm}^{-3}$ . The diffusion layers were produced by copper diffusion in extrinsic and intrinsic material. In the extrinsic semiconductors the diffusion was done at  $800^\circ\text{C}$  for 5 hours, resulting in diffusion  $\pi$ -layers. Diffusion conditions for the intrinsic material were  $1000^\circ\text{C}$  for 10 hours. This resulted in copper doping through the entire thickness of the p-GaAs specimen. The diffusion was done at an arsenic vapor pressure of 0.1 atm and 1.0 atm, and the specimens were cooled at rates of about  $200^\circ\text{C/s}$  (rapid cooling) and  $0.1^\circ\text{C/s}$  (slow cooling). The Hall effect and electrical conductivity of the specimens at 300 K were studied with etching of layers, the average concentration  $\bar{p}$  and mobility  $\bar{\mu}$  of charge carriers in the layers were calculated, the energy of ionization of defects was determined from the temperature dependence of  $\bar{p}$  and  $\bar{\mu}$ , and the intrinsic photoconductivity and spectral distribution of photoconductivity were measured. It was found that charge carrier concentration decreases with increasing depth of the layer regardless of initial electron concentration or arsenic vapor pressure. Hole concentration and mobility are independent of arsenic vapor pressure. The effective lifetime of holes decreases with increasing distance from the surface, showing an increase in the concentration of recombination centers with increasing depth. The results of the study show that copper interacts differently with point defects and with impurities at different depths from the surface of the specimen. The same types of defects are observed in diffusion layers and bulk-doped specimens for different rates of diffusion. Two types of defects show decreasing concentration with depth:  $(V_{\text{As}} \text{Cu}_{\text{Ga}} V_{\text{As}})^-$  and  $(\text{Cu}_{\text{Ga}}^2 \text{D}^+)^-$ . In addition, centers are also observed that increase in concentration with depth of the layer. These are centers of volumetric recombination that determine the effective lifetime of holes. The authors thank I. V. Kamenskaya for doing the preparatory experiments. Figures 4, references 11: 8 Russian, 3 Western.



USSR

SPECTRUM OF EXCITATIONS AND OPTICAL PROPERTIES OF A SEMICONDUCTOR IN THE  
FIELD OF A STANDING ELECTROMAGNETIC WAVE IN A HOMOGENEOUS MAGNETIC  
FIELD

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 19, No 12, Dec 77 pp 3530-  
3537 manuscript received 26 May 77

KREMLEV, A. N., POPOV, V. D. and YAKOVLEV, V. P., Moscow Engineering  
Physics Institute

[Abstract] Interaction of the electrons of a semiconductor with a resonant electromagnetic field leads to a gap in the spectrum of quasiparticle excitations. It was recently shown by A. S. Aleksandrov et al. ["Zhurnal eksperimental'noy i teoreticheskoy fiziki," Vol 72, 1977, p 1913] that in the case of a standing wave, spatial nonhomogeneity of the field results in the gap being replaced by a continuous reduction in the density of states. In this paper, the results of Aleksandrov et al. are generalized to the case where the standing wave is accompanied by a constant homogeneous magnetic field. In a strong magnetic field when the gyromagnetic frequency is much higher than the characteristic frequency of transition of an electron between bands under the action of the wave, the energy spectrum is determined by intermixing of like Landau levels from the valance band and the conduction band, and is a sequence of allowed and forbidden bands. The structure of the spectrum of excitations can be easily varied by changing the angle between the magnetic field and the wave vector. An examination is made of the optical properties of a semiconductor in the state of saturation. As a result of electron-electron and electron-phonon collisions, the distribution function of the quasiparticles relaxes to a steady state that is Fermi distribution with zero chemipotential. The coefficients of absorption and amplification of an additional weak wave on characteristic frequencies of the system are calculated for this state. Figure 1, references 11 Russian.

PRODUCING ZnS FILMS BY LASER EVAPORATION AND EXAMINING THEIR PROPERTIES  
BY OPTICAL MICROSCOPY

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 838-842 manuscript received 22 Apr 77

POZINYAK, N. I. and MYL'NIKOV, V.S.

[Abstract] The feasibility study concerning the use of a CO<sub>2</sub>-laser for producing ZnS films by the evaporation method was continued: radiation from such a laser, 25 W, was transmitted to a vacuum chamber through a NaCl window and here focused on the target by means of a metallic spherical mirror or a NaCl lens. The target consisted of ZnS pellets or grade KO-2 ZnS ceramic. The thickness of ZnS films deposited upon evaporation, on substrates of glass, quartz, fluorite, or alkali-halide salts was either measured with an MII-9 microinterferometer or calculated from the transmission spectra recorded with an SAGU-4 spectrophotometer. The structure of the film surfaces was examined under an MBI-15 microscope in the bright field and in the dark field, by the method of reflection or by the method of phase contrast. Within 10-15 min the target temperature stabilized at 1000°C and the substrate temperature stabilized at 65°C, while the pressure inside the chamber returned to 10<sup>-6</sup>-10<sup>-5</sup> mm Hg after a short transient rise due to irradiation. The results of this experiment indicate that the formation of the film structure depends not only on the process conditions but also on the substrate material. Homogeneous films build up on all substrates, thin or thick, within 15 min. After a longer treatment, however, crystallites form on quartz and fluorite (larger and sooner on quartz). The authors thank A.M. Bonch-Bruyevich for interest in this study. Figures 5; references 5: 4 Russian, 1 Western.

USSR

# HIGH-EFFICIENCY HETEROJUNCTION LIGHT EMITTING DIODES OF THE Al-Ga-As SYSTEM

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 809-817 manuscript received 18 Jul 77

ALFEROV, ZH.I., ANDREYEV, V.M., GARBUZOV, D.Z., DAVIDYUK, N.YU., YEGOROV, B.V., PUSHNYY, B.V., and CHICHUA, L.T., Physicotechnical Institute imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] An experimental study was made of heterojunction light-emitting diodes with an  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  ( $0 < x < 0.15$ ) mesa structure. These structures were produced by liquid-phase epitaxy and extrusion at  $950\text{--}1000^\circ$  on n-GaAs substrates. The specimens were of three kinds: those with a low potential barrier between n-emitter and active region (recombination zone penetrating the n-emitter), those with the energy gap of the active layer wider than that of the p-emitter (reradiation photoluminescence from part of the p-emitter), and those with high potential barriers between both emitters and the active region). The quantum efficiency as a function of the current density was measured in various configurations. The data reveal the effect of the diode geometry, especially with respect to the passive n-region, the effect of current leads and their contact area, the effect of reradiation from the p-emitter, the effect of the doping level in the active region, the effect of the refractive indexes of the two emitters, and the effect of the coating geometry. The peak quantum efficiencies recorded were: 34% at a direct-current density of  $10 \text{ A/cm}^2$  in the case of diodes with two high potential barriers and with a spherical coating of epoxy resin, 45% at a pulse-current ( $0.5 \mu\text{s}$ ) density of  $100 \text{ A/cm}^2$  in the case of diodes with one low potential barrier and with a spherical coating of chalcogenide glass. The respective efficiencies were lower with flat coatings. Reradiation was found to contribute about one third to the total light intensity, over the  $1.4 < h\nu < 1.62 \text{ eV}$  spectrum with a peak at  $1.47\text{--}1.48 \text{ eV}$ . The authors thank G.V. Zemlyannikova and M.M. Anikin for helping with the preparation of specimens, S.G. Konnikov for making the x-ray microspectral measurements, and V.M. Tuchkevich for his unwavering interest in this study. Figures 9; tables 1; references 14: 12 Russian, 2 Western.

## STANDARD SEMICONDUCTOR DIODES AS FAST DETECTORS OF LONGWAVE LASER RADIATION

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 793-796 manuscript received 7 Feb 77

ZELENOV, A.A., MARMUR, I.YA., OKSMAN, YA.A., and SEMENOV, A.A.

[Abstract] The photo-emf response of standard germanium photodiodes (FD-1) and GaP LED's (AL-102V) to laser pulses at the  $10.6 \mu\text{m}$  wavelength was recorded and measured with a two-beam oscillograph. The radiation source was a CO<sub>2</sub>-laser supplying pulses of  $0.12 \mu\text{s}$  or longer duration. The diodes were immersed in liquid nitrogen, together with a reference probe, and forward biased. The performance characteristics of these diodes as detectors include a sensitivity up to 4400 mV/kW (special FD-1) or 3000 mV/kW (AL-102V) with proper bias voltage and receiver resistance, a linear range up to 1 kW (much less sensitive plain FD-1) or 0.5 kW (AL-102V), and a maximum response speed of  $5 \cdot 10^{-8} \text{s}$  (all diodes) at 77 K. The active surface area of FD-1 photodiodes is  $2 \text{ mm}^2$ , that of AL-102V LED's is  $0.8 \times 0.8 \text{ mm}^2$ . Figures 2; tables 1; references 7: 6 Russian, 1 Western.

PHOTOELECTRIC CHARACTERISTICS OF In<sub>2</sub>Se WITH p-n JUNCTIONS FORMED BY LASER RADIATION

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 23, No 4 Apr 78 pp 685-687 manuscript received 6 Oct 77

BOBITSKIY, YA.V., GERTOVICH, T.S., KIYAK, S.G., FLYATSKO, G.V., and TOVSTYUK, K.D., L'vov Division of Mathematical Physics, Institute of Mathematics at the Academy of Sciences of the Ukrainian SSR, Chernovitsy Division of Semiconductor Material Science, Institute of Semiconductors at the Academy of Sciences of the Ukrainian SSR

[Abstract] Experimental data are evaluated pertaining to interaction between laser radiation and In<sub>2</sub>Se single crystals. The photoelectric characteristics of resulting p-n junctions are also shown. The crystals were grown by the Czochralski method and then annealed. Specimens with n-type conductivity and a carrier concentration within  $10^{14}$ - $10^{16} \text{ cm}^{-3}$  were irradiated across the (100)- plane. The photoelectric spectrum reflects the complex structure of the conduction band. The photosensitivity remains constant between energy levels of optical transitions. The width of the forbidden band is 0.62 eV, as has also been found earlier by absorption measurements. Figures 1; references 9: 6 Russian, 3 Western.

USSR

UDC 621.378.32

FARADAY ROTATION IN THE ACTIVE MEDIUM OF A PHOTODISSOCIATION IODINE LASER (AMPLIFIER)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 312-317  
manuscript received 22 Feb 77

KISELEV, V.M., BOBROV, B.D., GRENISHIN, A.S., and KOTLIKOVA, T.N.

[Abstract] Expressions are derived for the angle of Faraday rotation of the polarization plane, specifically under various conditions of operation of a photodissociation iodine laser (amplifier) in an axial magnetic field. The analysis accounts for Zeeman splitting of the  $F=3 \rightarrow F=4$  transition as well as Lorentz and Doppler line broadening. The numerical calculations on this basis have been verified experimentally. According to these measurements, it also appears feasible to use the appreciable Faraday rotation of the polarization plane in an alternating axial magnetic field for additional narrowing of a magnetically controlled emission pulse from such a laser. This requires an anisotropic element such as a Glan-Foucault prism inside the resonator cavity. The results of this study can, furthermore, be useful in the design of monopulse multistage iodine lasers with magnetic suppression of amplification within the active medium as a means of preventing premature excitation of the amplifier stages. The authors thank I.M. Belousova for her interest in this study. Figures 4; references 16: 9 Russian, 1 German, 6 Western.

USSR

UDC 621.378.4

CHANGES IN THE CONDITIONS OF OPTIMUM FOCUSING OF POWERFUL LASER BEAMS DUE TO FREQUENCY DOUBLING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 460-462  
manuscript received 1 Sep 77

GRIN', YU.G., KARAMZIN, YU.N., and SUKHORUKOV, S.P., Institute of Applied Mathematics, USSR Academy of Sciences, Moscow

[Abstract] The efficiency of a low-power optical frequency doubler can be increased many times by optimum focusing. The conditions of optimum beam focusing are established here, on the basis of a computer experiment, for single-mode second-harmonic lasers on  $\text{LiNbO}_3$  crystals with an output power 20-500 times higher than the pumping power. A semisymmetric such second-harmonic laser with a Gaussian pumping beam is described by the quasi-optical dimensionless equations for slowly varying amplitudes of the electric field

intensity, these equations being solved first for the case of noncritical synchronism and then for the case of critical synchronism. The resulting optimization is not ultimate, because of certain approximating assumptions made here with regard to diffraction loss and crystal nonlinearity. Figures 3; references 5: 2 Russian, 3 Western.

USSR

UDC 621.314.26+548.75

RADIATION AT THE DIFFERENCE FREQUENCY OF TWO CO<sub>2</sub>-LASERS IN A ZnSe CRYSTAL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 444-446  
manuscript received 2 Aug 77

BOBROVSKIY, A.N., MYL'NIKOV, G.D., and SOBOLENKO, D.N.

[Abstract] A cubic ZnSe crystal with a mirror and a diffraction grating was used for noncollinear cophased mixing of radiation from two synchronous CO<sub>2</sub>-lasers, to produce radiation at the difference frequency and thus tunable into the far infrared range of wavelengths. Proper matching of the two frequencies resulted in radiation at wavelengths from 5000 to 200  $\mu$ m, with discrete tuning possible in 5  $\mu$ m steps. Further increase of the wavelength was not quite feasible because of strong attenuation. The performance of a ZnSe crystal is compared with that of a GeAs crystal. The authors thank V.A. Mishchenko and V.A. Roslyakov for discussing the results of this study. Figures 2; tables 1; references 6: 1 Russian, 5 Western.

USSR

UDC 534.222.2

EXPERIMENTAL STUDY OF THE ACOUSTIC FIELD PRODUCED BY A MOVING OPTOACOUSTIC ANTENNA

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 457-459  
manuscript received 31 Aug 77

BUNKIN, F.V., MALYAROVSKIY, A.I., MIKHALEVICH, V.G., and SHIPULO, G.P.,  
Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] As a fluid absorbs laser radiation, acoustic waves propagate through the fluid from the spot which is heated by modulated radiation and acts as the antenna. As the spot moves over the surface of the fluid, the process of sound generation becomes more intricate. An experimental study of this phenomenon in water was made with a YAG:Nd<sup>3+</sup>-laser. Bell-

shaped milli-second light pulses were emitted at the  $1.06\ \mu\text{m}$  wavelength and harmonically modulated to 100% at a frequency equal to 100 kHz. The spot was moved around by means of a rotating mirror, at velocities ranging from subsonic to supersonic ones, and the amplitude-frequency characteristics of the acoustic field were measured in the direction of motion. The sound pressure, as a function of the antenna velocity, was found to peak sharply about 1.0 Mach. It thus appears feasible to generate high-intensity sound pulses and to control the characteristics of the acoustic field. The authors thank A.I. Bozhkov and A.A. Kolomenskiy for discussing the results of this study. Figures 2; references 5: 3 Russian, 2 Western.

USSR

UDC 621.3.038.8

#### PULSE TRAIN EXCITATION OF METAL VAPOR LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 452-454  
manuscript received 8 Aug 77

GORDON, YE.V., YEGOROV, V.G., and PAVLENKO, V.S., Institute of Chemical Physics, USSR Academy of Sciences, Moscow

[Abstract] Metal vapor lasers excited with short ( $10^{-7}$  s) electric discharges are characterized by high efficiency, high gain, and high emission power at various visible or ultraviolet wavelengths. A method has been developed here for varying the repetition rate of excitation pulses without changing the average power input to the discharge. The gist of this method is to form periodic pulse sequences of variable spacing. Inasmuch as the temperature stabilization time is usually much longer than the intervals between pulse sequences, the average discharge power is proportional to the ratio of repetition rate to pulse spacing. The operating temperature can thus be easily maintained proportional to the pulse spacing. Also the number of pulses per sequence can be widely regulated, which is very convenient for emission analysis. The method was applied to a CuCl vapor laser with a nominal power rating of 1 kW, excited with current pulses with a risetime of 20 ns and amplitudes up to 80 A, operating at frequencies within 10-12 kHz at temperatures over the 310-700°C range without external cooling. Figures 3; references 6: 4 Russian, 2 Western.

## FEASIBILITY OF USING INTERMETALLIC COATINGS FOR THE PRODUCTION OF HIGH-POWER OPTICS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 446-449  
manuscript received 3 Aug 77

APOLLONOV, V.V., BARCHUKOV, A.I., OSTROVSKAYA, L.M., RODIN, V.N., and KHOMICH, V.YU., Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Production of laser mirrors is a major problem in power optics engineering. Physical and chemical properties of metals make them the most suitable materials for this application, especially copper, but the unavailability of an ideal one requires other solutions such as multilayer composites or intermetallic compounds. Here intermetallic compounds of the electronic type with  $\delta$ -,  $\gamma$ -, and  $\epsilon$ -phase structures are considered: copper with aluminum, gallium, silicon, tin, or germanium. The production of such coatings is feasible by vacuum evaporation and condensation only. Their optical properties (high specular reflectivity), mechanical properties (strength and elasticity), as well as oxidation resistance after being polished to a nanometer microroughness make them very suitable for high quality power optics. Figures 2; tables 1; references 6: 5 Russian, 1 Western.

## DYNAMICS OF LASER BEAM COMPRESSION DUE TO TRANSIENT THERMALLY INDUCED SELF-FOCUSING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 438-440  
manuscript received 17 Jun 77

KASK, N.YE., RADCHENKO, V.V., FEDOROV, G.M., and CHOPORNYAK, D.B., Scientific Research Institute of Nuclear Physics, Moscow State University imeni M.V. Lomonosov

[Abstract] Transient thermal self-focusing of radiation from a quasi-continuous neodymium laser in grade K8 optical glass was measured by high-speed interferometry. The critical self-focusing energy had been lowered by treating the glass with gamma radiation. The radial profile of the refractive index at some distance from the surface was determined at various instants of time and found to shrink continuously. The absorption coefficient was then calculated from experimental data according to the relation



$$\frac{C_p}{(\frac{dn}{dT})} \frac{I(W)}{W}$$

(C specific heat,  $\rho$  density,  $dn/dT$  temperature coefficient of the refractive index,  $I(W)/W$  slope of the laser beam section vs energy line). Theoretical curves were also plotted on the basis of the solution to the quasi-optical equation for weakly absorbing media. Figures 4; references: 8 Russian.

USSR

UDC 621.387.330.3

#### ULTRAVIOLET DYE LASERS WITH PUMPING FROM EXCIMER LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 424-425  
manuscript received 24 Jun 77

LISITSYN, V.N., RAZHEV, A.M., and CHERNENKO, A.A., Institute of Semiconductor Physics, Siberian Division of the USSR Academy of Sciences, Novosibirsk

[Abstract] The results of experiments are reported concerning the use of lasers on halides of noble gases for pumping various organic ultraviolet dyes. Most efficient (about 30%) was pumping paraterphenyl with a KrF (248.5 nm) laser to stimulate emission tunable over the 334.0-362.0 nm range, with a peak power of 80 kW attainable at a somewhat lower efficiency. Less efficient was pumping paraterphenyl with an XeBr laser (281.8 nm). Least efficient was pumping 1,4-diphenyl butadiene (354.0-360.0 nm emission) and polyphenyl oxide (370.0-380.0 nm emission) with a KrF laser. The authors thank V.P. Chebotayev for stimulating this research. References 7: 1 Russian, 6 Western.

USSR

UDC 621.378.335

FEASIBILITY OF PRODUCING A LASER AT VISIBLE WAVELENGTHS ON SULFUR MOLECULES WITH CHEMICAL PUMPING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 421-423  
manuscript received 3 Jun 77

BASHKIN, A.S., KUPRIYANOV, N.L., and ORAYEVSKIY, A.N., Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] New data have been obtained on chemical pumping of sulfur molecules for producing a laser at visible wavelengths. These data contain the quantum output of an  $M=Ar$  recombination, estimated from the potential energy and the population of the  $B^3\Sigma_u^-$  state. Several mechanisms for triggering the chemical reactions which produce  $S_2(B)$  molecules have been considered, namely: photo (ultraviolet) dissociation of  $COS$ ,  $CS_2$ , or  $H_2S$ , adiabatic cooling of thermally dissociated sulfur vapor, sulfur concentration in a chemical reaction, and chemical pumping of the  $B^3\Sigma_u^-$  state, in a bimolecular reaction. The authors thank dr. R.V.F. Gross for helpful discussion. Figures 1; references 11: 4 Russian, 7 Western.

USSR

UDC 621.373.826.038.823

CHEMICAL FLUORINE-HYDROGEN LASER WITH ELECTRON-BEAM TRIGGERING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 415-417  
manuscript received 10 May 77

BARANOV, V.K., DEMIDENKO, YU.N., ZELENSKIY, K.F., KORMER, S.B., PEGOYEV, I.N., TROSHKIN, I.A., TSUKERMAN, V.A., SHCHETININ, YE.N., and YUSHKO, K.B. (deceased)

[Abstract] The results of experiments are reported concerning the feasibility of a chemical HF-laser with excitation by an electron pulse of 30 ns duration. The electron beam necessary for triggering the laser was formed by an annular accelerator cathode and injected into the cell through a titanium membrane, then guided along the axis and deflected by means of two solenoids respectively. The composition of the active gas mixture was  $F_2:O_2:SF_6:H_2=3.6:1.4:1.0:1.0$ , the energy of the laser pulse depending on the pressure and its power as well as the electron excitation current peaking after approximately 50 ns under a pressure of 500 mm Hg. It is already feasible to thus produce laser pulses of 67 J energy ( $0.034 J/cm^3$ ) with a peak power of 660 MW at an electrical efficiency of 45% and a chemical efficiency of 1.6%. Figures 3; references 10: 5 Russian, 5 Western.

USSR

UDC 621.375.82+533.916

INTENSITY OF SATELLITES OF RESONANCE LINES OF HELIUM-LIKE IONS WITH  $Z=12-23$  IN AN X-RAY FIELD OF A LASER PLASMA

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 394-404  
manuscript received 16 Feb 77

BOYKO, V.A., PIKUZ, S.A., and FAYENOV, A.YA., Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A comparison is made between theoretical and experimental data pertaining to the intensity of satellites of resonance lines of He-like ions with  $Z=12-23$  (Mg, Al, Si, P, S, Cl, K, Ca, Sc, Ti, V). Theoretically these satellites occur as a result of either two-electron recombination or direct excitation. The relative intensities of these lines are thus determined by atomic constants as well as by plasma parameters. The experimental values, based on spectroscopic measurements and accurate within 10-40%, agree with the theoretical values to such an extent that calculations of decay probabilities and of autoionization cross-sections may be regarded as reliable enough for diagnosis of hot and dense laser plasmas. The authors thank N.G. Basov and O.N. Krokhin for interest in this study, also L.A. Vaynshteyn, A.V. Vinogradov, L.P. Presnyakov, U.I. Safronova, I.Yu. Skobelev, and Ye.A. Yukov for helpful comments. Figures 4; tables 1; references 18: 14 Russian, 4 Western.

USSR

UDC 621.375.9

COPPER VAPOR PULSE LASER WITH TRANSVERSE EXCITATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 381-387  
manuscript received 1 Feb 77

BOKHAN, P.A. and SHCHEGLOV, V.B., Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk

[Abstract] A high-temperature laser cell has been developed with copper vapor as the active medium and with transverse excitation. For a determination of its performance characteristics, as functions of the discharge parameters with either helium or neon serving as the buffer gas, the cell was placed inside an optical resonator tuned to yellow-green wavelengths. Excitation was supplied from a symmetric circuit with storage and discharge capacitors and pulse trimming. The output energy and the efficiency of this laser were measured under varying gas pressure and cell temperature, at various voltages in the excitation circuit and various time delays

between two successive pulses. With helium as the buffer gas, the output energy peaked at a pressure of 14 mm Hg, in the case of neon it peaked at 10 mm Hg and then again at 470 mm Hg. The maximum output energy of  $55 \mu\text{J}/\text{cm}^3$  was obtained with neon under 470 mm Hg, at an efficiency approaching 1%. A comparison with lasers with longitudinal excitation, based on calculations, confirms that in the latter case emission starts at much lower electric field intensities, but there is no peak emission within the high-pressure range. Transverse excitation requires, moreover, special means for preventing a localization of discharge. Figures 7; references 3: 2 Russian, 1 Western.

USSR

UDC 621.378.325

THEORY OF A TWO-CAVITY PARAMETRIC OPTICAL OSCILLATOR WITH MULTIMODE PUMPING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 331-336  
manuscript received 28 Feb 77

DZHOTYAN, G.P. and D'YAKOV, YU.YE., Moscow State University imeni M.V. Lomonosov

[Abstract] Parametric optical oscillators can serve as sources of coherent electromagnetic radiation at wavelengths for which lasers are not available. Here the dependence of the excitation threshold on the spectral distribution of pumping intensity is examined and the possibility of a non-monotonic dependence of this threshold on the resonator parameters is demonstrated. Accordingly, the excitation threshold and the transient processes are calculated first for single-mode and then for multimode pumping of a two-cavity parametric optical oscillator. The results indicate that the excitation threshold as well as the shape of emission pulses and the efficiency of nonlinear conversion of broadband pumping to narrow-band signals depend not only on the mean pumping intensity but also on the width and the shape of the pumping spectrum. It thus appears feasible, by increasing the mean pumping intensity, to make the efficiency of nonlinear conversion less dependent on the multimodality of pumping. A higher mean intensity, in the case of multimode pumping, can be achieved either by decreasing the difference between mode frequencies, i.e., narrowing the pumping spectrum, or by broadening the resonance line of the cold idler-wave cavity. Figures 4; references 10: 6 Russian, 4 Western.

USSR

UDC 621.378.385

# CHANGE IN THE REFLECTIVITY OF METALLIC REFLECTORS DUE TO LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 325-330  
manuscript received 24 Feb 77

BESSARAB, A.V., ZHIDKOV, N.V., KORMER, S.B., PAVLOV, D.V., and FUNTIKOV, A.I.

[Abstract] An experimental study was made of changes in the reflectivity of copper, aluminum, and stainless steel due to laser radiation. A neodymium laser with optomechanical Q-switching emitting bell-shaped pulses of 70 J with 400 ns duration was used for this purpose. Simultaneous measurement of the brightness temperature and photographic recording of the luminescence from the irradiated surface yielded data, accurate within  $\pm 10\%$ , according to which laser pulses do not affect the reflectivity of these metals until the energy density becomes sufficiently high for intensive evaporation. At the corresponding temperatures, moreover, specular reflection diminishes changing to diffuse reflection, but the overall reflection coefficient remains about the same. The latter decreases appreciably after the evaporated material has begun to flash. Figures 5; references 13: 9 Russian, 4 Western.

USSR

UDC 621.378.33

## A BARIUM VAPOR LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 319-324  
manuscript received 24 Feb 77

BOKHAN, P.A. and SOLOMONOV, V.I., Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk

[Abstract] A barium vapor laser operating at the 1.5  $\mu\text{m}$  wavelength belongs in the category of those operating with a self-limited transition. An experimental study was made to determine the output characteristics of such a laser depending on the excitation parameters and on the diameter of the gas-discharge tube. Excitation was supplied through high-voltage pulses recurring at frequencies from 100 to 400 Hz, with helium under a pressure of 20-25 mm Hg as the buffer gas. Increasing the tube diameter from 5 to 20 mm under the same excitation did not appreciably affect the output energy density, which had reached 8  $\mu\text{J}/\text{cm}^2$  at an efficiency of 0.16% with the optimum combination of capacitances and inductance in the excitation circuit. The emission power of this laser was found to increase with higher pumping voltage, but saturation occurring already below 10 kV

at temperatures below 700°C. The efficiency becomes maximum when the emission pulse begins to narrow down. The optimum vapor pressure increases with high voltage. These results indicate that a barium vapor laser will perform as well at near-infrared wavelengths as manganese and copper lasers within the yellow-green range. Figures 7; references 6: 5 Russian, 1 Western.

USSR

#### TWO-MODE LOCKING IN A STANDING-WAVE GAS LASER

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 73, No 2(8), Aug 77 pp 462-469 manuscript received 17 Mar 77

GONCHUKOV, S.A., YERMACHENKO, V.M., PETROVSKIY, V.N. and PROTSENKO, YE.D.,  
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[Abstract] The paper gives the results of a theoretical and experimental study of locking of two orthogonally polarized modes in a gas laser with different degrees of degeneration of the levels of the working transition. The theoretical analysis is based on the work of Yu. A. Vdovin et al. [Physics Institute of the Academy of Sciences imeni P. N. Lebedev, Preprint FIAN No 116, 1972] with consideration of degeneration of levels, elastic collisions of atoms and trapping of resonant emission. A helium-neon laser is considered with modes on neon transitions  $3s_2-3p_4$ ,  $3s_2-3p_2$  and  $2s_2-2p_1$  with moments of the upper and lower working levels of 1, 2; 1, 1; 1, 0 respectively. It is found that locking takes place in the vicinity of symmetric tuning of modes relative to the center of the line of amplification. It is shown that in the case of weak degeneration of the levels of the working transition (with moments of 1, 1 and 1, 0), mode locking is due to the influence of atomic collisions. The results of measurements are given for spectral and polarization characteristics of emission in the region of two-mode locking. Figures 3, references 6: 3 Russian, 3 Western.

USSR

UDC 621.378.34

EFFECT OF SUPERFLUORESCENCE ON THE PERFORMANCE OF LASERS WITH AMPLIFIERS  
ON DYES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 297-304  
manuscript received 14 Feb 77

NAROVLYANSKAYA, N.M. and TIKHONOV, YE.A., Institute of Physics, Academy  
of Sciences of the Ukrainian SSR, Kiev

[Abstract] A theoretical and experimental study was made of a laser-amplifier system on an organic dye with longitudinal pumping pulses (0.2 J over 30 ns) from a ruby laser. The gain is a function of the optical density of the dye solution and the optimum optical density, yielding the maximum gain, in turn depends on the pumping intensity. In the experiment gains of 9 and 35 were attained with the pumping energy divided respectively in the ratio 3:7 and 8:92 between laser and amplifier, the corresponding conversion efficiencies being 15 and 7%. The gain is also a function of the signal amplitude and decreases with increasing signal magnitude. Superfluorescence contributes to saturation with respect to conversion efficiency, especially at small signals but less at large signals. The theoretical interpretation of these results is based on the balance of energy levels in a dye molecule and on the equations of wave propagation through a nonlinearly amplifying medium. Figures 5; references 11: 4 Russian, 7 Western.

USSR

UDC 621.375.82

AMPLITUDE ASYMMETRY IN THE SPECTRUM OF STIMULATED EMISSION FROM DYE  
SOLUTIONS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 290-296  
manuscript received 20 Dec 76

BEZRODNYI, V.I., NAROVLYANSKAYA, N.M., and TIKHONOV, YE.A., Institute of  
Physics, Academy of Sciences of the Ukrainian SSR, Kiev

[Abstract] Experiments with ring lasers stimulated by nanosecond pumping pulses have revealed an asymmetry in the superfluorescence spectrum, which is found to be due to different intensities of forward and backward traveling waves. An interpretation is given here on the basis of beam compression in a nonlinearly absorbing medium and a solution to the fundamental differential equation for the steady-state superfluorescence intensity in such a medium. A numerical evaluation, furthermore, indicates that the spectra of a ring laser and the equivalent linear laser are not

of equal widths, because of different spectral compositions of the fluorescence at opposite ends of the amplifying medium. Figures 5; references 12: 7 Russian, 5 Western.

USSR

UDC 621.378

OBSERVATION OF SUPERSONIC RADIATION WAVES IN GASES UNDER THE ACTION OF CO<sub>2</sub> LASER EMISSION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 216-218 manuscript received 19 Jul 77

BOYKO, V.A., DANILYCHEV, V.A., DUVANOV, B.N., ZVORYKIN, V.D. and KHOLIN, I.V., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Previous research has demonstrated the feasibility of supersonic radiation waves of laser emission absorption with a velocity that exceeds that of conventional light-detonation waves. In this paper a study is done on supersonic radiation waves in xenon and argon that arise under the action of pulsed emission from a powerful CO<sub>2</sub> laser. An electron-beam-controlled laser was used in the experiments with aperture of 10x10 cm and output energy of about 100 J. The emission was focused on a graphite target by a spherical mirror. The target was placed in a chamber filled with different gases from pressures of 10<sup>-1</sup> mm Hg up to atmospheric pressure. These experiments are the first to demonstrate superdetonation absorption waves on  $\lambda = 10.6 \mu\text{m}$  in gases. The threshold of formation of supersonic radiation waves in argon and neon was found to be  $(3-4) \cdot 10^7 \text{ W/cm}^2$ . The velocities of the absorption waves exceeded those of light-detonation waves by a factor of  $\sim 10$  and  $\sim 7$  for argon and xenon respectively. The experiments were done under conditions closely approximating the planar one-dimensional case. Figures 2, references 5: 4 Russian, 1 Western.



USSR

UDC 621.382.3

RADIATIVE CHARACTERISTICS OF A SINGLE-CHANNEL INJECTION LASER BASED ON GaAs

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 211-214 manuscript received 14 Jul 77

KARGAPOL'TSEV, V.S., MALYGIN, YE. P., MALYSHEV, V.K., MOLOCHEV, V.I., NARZULLAYEV, K. N., NIKITIN, V. V., SEMENOV, A. S. and TALENSKIY, O. N., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The paper gives the results of studies of the radiative characteristics of laser structures based on gallium arsenide grown by a new technique that can produce an active region varying in width from a fraction of a micrometer to several tens of micrometers. These single-channel lasers operate at 77 K in the cw emission mode. Lasing action is on a single longitudinal mode over a wide range of injection currents. Maximum cw emission power is of the order of 50 mW. Single-channel injection lasers have high coherence with a coherence length of the order of 10 m. A comparison of the energy characteristics of lasers with active regions 6 and 200  $\mu\text{m}$  wide shows that single-channel diodes are 10 times as efficient in converting electric energy to coherent emission as the wide diodes. Figures 4, references 9: 4 Russian, 5 Western.

USSR

UDC 621.378.33

A PULSED STRONTIUM VAPOR LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 198-201 manuscript received 27 Jul 77

PLATONOV, A. V., SOLDATOV, A. N. and FILONOV, A. G., "Optika" Special Design Office of Scientific Instrument Making, Siberian Department, Academy of Sciences USSR, Tomsk

[Abstract] An experimental study is done on the lasing action of the strontium atom on  $\lambda = 6.45 \mu\text{m}$ . Lasers on self-limited transitions in metal atoms give high practical efficiency, high recurrence rate and high pulse power. A simplified diagram is given of the levels and transitions in the strontium atom and ion. The discharge tubes for the lasers operated in the self-heating mode and discharge excitation was by the Blumlein arrangement. The working capacitance was 620 pF and pulse recurrence rate was 20 kHz. The cavity was made up of a flat aluminized mirror and a plane-parallel plate of BaF<sub>2</sub>. Average emission power for a 10 mm discharge

tube 380 mm long was 1.2 W with efficiency of 0.1%. After 15-20 minutes of operation, 75% of the emission power is concentrated in the 6.45  $\mu\text{m}$  line. Since the emission of the strontium laser falls into one of the absorption bands of water, such a device could be used for remote localized determination of humidity in the atmosphere. Figures 3, references 5: 4 Russian, 1 Western.

USSR

UDC 621.378.325

CONCERNING THE MECHANISM OF LASER DESTRUCTION OF TRANSPARENT MATERIALS  
THAT IS DUE TO THERMAL EXPLOSION OF ABSORBING NONHOMOGENEITIES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 194-195 manuscript received at "Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki" 21 May 77, and at "Kvantovaya elektronika" 24 Jun 77

DANILEYKO, YU. K., MANENKOV, A. A. and NECHITAYLO, V. S., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Thermal explosion of absorptive nonhomogeneities is considered as a mechanism of laser destruction of transparent optical dielectrics. It is shown that thermal explosion of nonhomogeneities as small as  $10^{-6}$  cm is a sufficient condition for development of macrofractures in the matrix of the material. The explosion mechanism can be attributed to ultraviolet pre-ionization of the matrix surrounding the nonhomogeneity, generation of free carriers in the matrix, and additional induced absorption on these carriers. This absorption leads to explosion of the ionized region, and thus to propagation of the discharge. It is pointed out that a considerable part is played by induced absorption on a growing crack caused by charge separation on the walls of the crack (triboelectric process). Figure 1, references 6 Russian.

USSR

UDC 621.375.826

REPULSION OF BODIES FROM THE SURFACE OF THE WATER UNDER THE ACTION OF  
LASER RADIATION (VAPOR-LIGHT CUSHION)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 192-193 manuscript received at "Pis'ma v Zhurnal tekhnicheskoy fiziki" 3 Dec 76, and at "Kvantovaya elektronika" 2 Jun 77

ASKAR'YAN, G. A., DATSKEVICH, N. P., KARLOVA, YE. K., KONONOV, N. N., KUZ'MIN, G. P. and MANZON, B. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Two series of experiments were done on the repelling action of laser emission interacting with bodies on or near the surface of water. In the first series, a circular disk with area of about  $300 \text{ cm}^2$  and mass of 2 g was suspended at a height of 10 cm above the surface of the water and the emission from a  $\text{CO}_2$  laser with pulse energy of 1.5-2 kJ and duration of 1  $\mu\text{s}$  was obliquely incident on the water surface from above, the point of incidence being directly beneath the ballistic disk. For incident energy density of 5-7  $\text{J/cm}^2$ , the disk rose to a height of 8 cm, which corresponds to initial velocity of about 1300 cm/s (accounting for air resistance could increase this figure). This series of experiments also included measurements with transparent (Mylar) disks in which the incident radiation was perpendicular to the surface of the water through the disk. In the second series, a GOS-1000 neodymium laser was used with pulse energy of 1 kJ for a duration of 1 ms. The laser beam was directed through the water to the underside of the target floating or submerged in the water. Three types of bodies were studied: a flat copper disk, a copper cylinder with one flat face, and a black sponge rubber disk. The targets were thrown upward to a distance of up to 2.5 m. Possible practical applications in propulsion systems are considered. Figures 2, references 2 Russian.

USSR

UDC 621.373.8.038.825

A LASER THAT EMITS DOUBLE PULSES WITH CONTINUOUS ADJUSTMENT OF TIME  
SEPARATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 179-181 manuscript received 13 May 77

VARTAPETOV, S. K., VASIL'YEV, V. P., VOLYAK, T. V., KRASYUK, I. K., MOISEYEV, YU. YE., PASHININ, P. P. and SAVEL'YEV, V. G., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The paper describes a laser that emits two giant pulses with smooth regulation of the time interval between them. The active element

is a neodymium glass rod with two independent channels of stimulated emission that are isolated by diaphragms at the output end of the rod. The delay of the second channel relative to the first is determined by the setting of a rotating prism in a special pulsed optical-mechanical shutter that uses part of the energy of the pulse current in the discharge circuit of the pumping tube for the laser to rotate the prism. The emitted pulses have an energy of 0.3 J and duration of 25-50 ns, and the interval between them can be varied continuously from 0 to 15  $\mu$ s. The device can be used to synchronize triggering of various devices and to photograph processes and objects over a wide time range. Figures 4.

USSR

UDC 621.378.325

#### A LEAD-VAPOR LASER

Tomsk IZVESTIYA VUZov: FIZIKA in Russian No 10(185), 1977 pp 146-149  
manuscript received 8 Apr 77

KIRILOV, A. YE., KUKHAREV, V. N., SOLDATOV, A. N. and TARASENKO, V. F.,  
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Sciences of the USSR

[Abstract] The authors investigate the energy parameters of a "self-heating" lead-vapor laser ( $\lambda = 722.9$  nm) as a function of the parameters of the discharge circuit at high current pulse recurrence rates. The experimental laser is a modification of the Blumlein circuit on ceramic capacitors. The distance between electrodes in the gas-discharge tubes was 300 and 600 mm, and the diameters were 2.5 and 10 mm. The results of optimization with respect to the pressure of the buffer gas and heating efficiency are compared with the results of optimization of the discharge circuit, pressure and excitation pulse frequency. In the latter case, the efficiency is 6 times higher and the specific average power is 8 times higher than in the former case. Figures 5, references 6: 5 Russian, 1 Western.

USSR

UDC 621.378.3

ON THE EFFICIENCY OF LASER PUMPING WITH XENON FLASH TUBES WITH INTERFERENCE COATINGS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 1(67), Jan 78 pp 174-176 manuscript received 11 May 77

BARANOV, S. A., KOLPAKOVA, I. V., KONONOVA, M. YU., MAK, A. A. and MOTOVILOV, O. A., deceased

[Abstract] Experiments are done on the feasibility of increasing the efficiency of neodymium glass lasers by self-heating of the plasma. Theoretical calculations have shown that at the appropriate temperatures and coefficients of absorption of the plasma the efficiency of xenon flash tubes as pumping sources for neodymium glass lasers can be increased by a factor of 1.5-2. The IFP-800 and IFP-2000 lamps were studied. Dielectric coatings were applied by sputtering. Wide-band reflecting mirrors were applied to the tube envelopes in the form of alternating layers of  $ZrO_2$  and  $SiO_2$  with decreasing thickness. The results show that the use of interference coatings that reflect ultraviolet and pass the radiation of absorption bands of neodymium glass can increase the efficiency of lasing action by 20-60%.

USSR

UDC 621.378.9:621.371

WANDERING LASER BEAM IN A TURBULENT ATMOSPHERE. I. PROBABILITY DENSITY FUNCTION OF POWER FLUCTUATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 152-155 manuscript received 27 Jul 76, after revision 30 May 77

TAKLAYA, A. A., Tallin Polytechnical Institute

[Abstract] When laser emission propagates in the turbulent atmosphere the energy is redistributed within the beam and shifting (wandering) of the beam as a whole takes place. In this article expressions are derived for the probability distribution and the moments of distribution of intensity fluctuation with wandering of a laser beam that has log-normal fluctuations. The form of the distribution and the values of the moments depend on two parameters: one characterizing the strength of the log-normal fluctuations, and the other characterizing the strength of fluctuations that arise during wandering of the beam. Figures 2, references 11: 4 Russian, 7 Western.

USSR

UDC 621.328.9:621.391.133

WANDERING LASER BEAM IN A TURBULENT ATMOSPHERE. II. ERROR PROBABILITY  
IN RECEPTION OF A BINARY SIGNAL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 155-158 manuscript received 9 Sep 76, after revision 30 May 77

TAKLAYA, A. A., Tallin Polytechnical Institute

[Abstract] On the basis of the results of the preceding paper [see "Kvantovaya elektronika," Vol 5, No 1(67), Jan 78 pp 152-155] the author examines the influence that a combination of log-normal signal fluctuations and the fluctuations due to wandering of the laser beam has on direct reception of a binary signal. The binary signal is transmitted by pulse modulation of intensity or polarization, and is received by an optical device with sensitivity limited by thermal noises. The pulse recurrence rate is taken as greater than the signal fluctuation in the communication channel, which is true if the pulses are transmitted at a rate of more than  $10^4/s$ . Log-normal fluctuations are characterized by the parameter  $\sigma$ , and fluctuations due to beam wandering are characterized by  $\alpha$ . Numerical integration is used to find the mean square error as a function of the signal-to-noise ratio for different values of these parameters for different modes of reception. It is found that signal power can be reduced if the threshold-tracking or polarization modulation modes are used. Figure 1, references 6: 2 Russian, 4 Western.

USSR

UDC 621.378.4

PHOTOGRAPHIC REGISTRATION OF THE EMISSION SPECTRUM OF A MONOPULSE CO<sub>2</sub>  
LASER WITH PARAMETRIC CONVERSION ON A PROUSTITE CRYSTAL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 128-131 manuscript received 22 Feb 77

LOMZIN, A. F., GOLOVEY, M. I., KOVALEV, V. I., MASH, D. SH., deceased, MOROZOV, V. V., ORAYEVSKIY, A. N. and FAYZULLOV, F. S., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] A proustite crystal (Ag<sub>3</sub>AsS<sub>3</sub>) is used to achieve parametric up-conversion of IR emission from a CO<sub>2</sub> laser into the range of sensitivity of photographic materials for the first reported light-sensitive recording of the spectrum of stimulated emission of such a laser in a single pulse. The signal source was a CO<sub>2</sub> pulse laser with transverse discharge having pulse energy of no more than 100 mJ. Rise time to the initial peak was

200 ns, and the "tail" of the pulse had a duration of up to 6  $\mu$ s. Pumping was by a ruby laser with pulses synchronized to the signal laser within 200 ns. Both laser beams were focused on the proustite crystal by lenses. The width of the conversion band is about 1  $\mu$ m in the 10.6  $\mu$ m region with coefficient of energy conversion of  $3 \cdot 10^{-3}$ . The minimum energy per line that can be registered in the spectrum is 0.25 mJ with spectral resolution of  $0.3 \text{ cm}^{-1}$ . Figures 3, references 12: 8 Russian, 4 Western.

USSR

UDC 621.373.826.038.823

#### SPACE-TIME EVOLUTION OF A CATHODE LAYER IN ELECTRON-BEAM-CONTROLLED LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 114-121 manuscript received 6 Jul 77

ALEKSANDROV, V. V., KOTEROV, V. N., PUSTOVALOV, V. V., SOROKA, A. M. and SUCHKOV, A. F., Computing Center of the Academy of Sciences USSR, Moscow, Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow, the Moscow Institute of Radio Engineering, Electronics and Automation

[Abstract] A study is done on the space-time evolution of a cathode layer of a semi-self-maintained glow discharge in pure nitrogen in the range of parameters typical of high-power electron-beam-controlled lasers: pressure about 1 atmosphere, degree of ionization  $10^{-9}$ - $10^{-7}$ , reduced electric field  $3$ - $13 \text{ V} \cdot \text{cm}^{-1} \cdot \text{mm Hg}^{-1}$ . An estimate is found for the change in the thermodynamic state of the neutral component of the plasma in the course of discharge development. It is shown that the parameters of the plasma and the electric field in the cathode layer reach steady-state values in four stages: initial plasma polarization, development of powerful impact ionization and formation of an emitting layer at the cathode, steadying of the emitting layer and steadying of the external part of the cathode layer. It is found that in the investigated range of parameters, the establishment of the cathode potential drop and electric field intensity at the cathode is an oscillatory process that involves establishment of the space charge in the emitting layer. It is shown that with the passage of time the neutral component of the plasma close to the cathode is strongly overheated. Estimates confirm that the hydrodynamic motion of the gas that arises due to overheating should have an appreciable effect on the later stages of discharge development. The authors thank V. A. Danilychev for support and interest, M. A. Savchenko for discussing the results, and A. B. Romanov and Ye. P. Glotov for useful discussions. Figures 5, references 15: 11 Russian, 4 Western.

## CONCERNING THE ACTION OF LASER EMISSION ON MATERIALS OVER A WIDE RANGE OF ARGON PRESSURES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 89-98  
manuscript received 21 Dec 76

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[Abstract] An experimental study is done on some particulars of interaction of laser emission with solid targets at high argon pressures. The laser emission was injected into a high-pressure chamber and then focused by a lens onto the surface of targets of different materials. The processes taking place in the chamber were recorded by high-speed photography. The neodymium laser pulse duration was close to 1 ms, and the flux density in the focal spot was about  $10^6$ - $10^7$  W/cm<sup>2</sup>. The targets were aluminum, molybdenum and stainless steel plates 1-2 mm thick, graphite plates 2 mm thick, and plates of polished silicon 0.1 mm thick. The pressure in the chamber was varied over a range of 1-130 atmospheres. It was found that an increase in pressure of argon changes the way that the focused radiation acts on targets of different materials due to the formation of a plasmoid over the surface of the target. The physical characteristics of the targets have a considerable effect on the evolution of the plasma cloud and on the nature of shielding of the surface. The mechanism of this influence involves partial absorption of the laser radiation in the plasma and refraction of the laser beam. A change in the flux density of the radiation has an appreciable influence on the rates of propagation, geometric parameters and other characteristics of the plasmoid. The action of laser radiation on materials in an argon atmosphere differs from the analogous action for molecular gases. This is due to the different mechanisms of discharge propagation and the chemical activity of the molecular (nitrogen) plasma. Figures 5, references 8: 4 Russian, 4 Western.



USSR

UDC 621.373.8.038.823:535.375

INFLUENCE OF BACKSCATTERING ON THE OPERATION OF A RING LASER WITH METHANE CELL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 75-82 manuscript received 30 Jan 77

ANDRONOVA, I. A., MAMAYEV, YU. A. and MARKELOV, N. A., Institute of Applied Physics, Academy of Sciences USSR, Gor'kiy

[Abstract] An examination is made of the influence that difference in storage factors and coupling of opposed waves via scattering have on the spectral position of "competitive" methane resonances that should be square when the storage factors are equal and the coupling is disregarded. The theoretical analysis assumes small excesses of the lasing threshold and coupling that does not appreciably alter the amplitudes of the opposed waves. It is experimentally shown that with a change in the phase of backscattering that is close in magnitude to the internal coupling due to back scattering by defects in optical elements, the extremum of the peak may be shifted by 300-500 Hz. The authors thank I. L. Bershteyn for constructive criticism and review of the manuscript. Figures 3, references 11 Russian.

USSR

UDC 621.378.325

MODES OF A COMPOUND RING CAVITY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 63-67 manuscript received 16 Feb 77

ARENDT, V. G., GODENKO, L. P., DANILEYKO, M. V. and MASHKEVICH, V. S., Institute of Physics, Academy of Sciences UkrSSR, Kiev

[Abstract] A standard electrodynamic technique is used for studying a compound ring cavity comprising two cavities with a common semitransparent plate ("window"). Expressions are derived that describe the frequencies and amplitudes of modes of this system. An analytical solution is found for these equations in the approximation of singular permittivity for the window. It is shown that the pressure of coupling in a system of two ring cavities considerably alters the spectrum of the system as compared with that of each of the cavities. The spectrum of the system becomes non-equidistant, and the fields of the modes are concentrated in one of the cavities, depending on mode frequency. It is noted that the effect of nonuniform distribution of the field of a mode with respect to the

component cavities may be used in precision studies of the characteristics of media that have light losses much higher than the gain of the active medium. By placing a passive medium in the cavity where the mode amplitude is low, one can appreciably reduce the harmful influence of this medium on lasing action. Figure 1, references 7: 4 Russian, 3 Western.

USSR

UDC 535.345.6:621.375.826

#### ON THE RESISTANCE OF DIELECTRIC INTERFERENCE MIRRORS TO THE ACTION OF LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 44-50  
manuscript received 1 Feb 77

ZVEREV, G. M., KOLODNYY, G. YA. and PORYADIN, YU. D.

[Abstract] A study is done on the resistance of multilayer dielectric mirrors of  $\text{TiO}_2$  and  $\text{SiO}_2$  to destruction by laser radiation both when the emission is reflected and when it is transmitted through the mirror. The mirrors studied were fourteen-layer structures with alternating quarter-wave layers of  $\text{SiO}_2$  and  $\text{TiO}_2$  and an outside half-wave layer of  $\text{SiO}_2$ . Four types of mirrors were made with optical thicknesses corresponding to wavelengths of 0.53, 0.69, 1.06 and 2.12  $\mu\text{m}$ . A YAG:Nd laser was used with Q-switching and a fundamental wavelength of 1.06  $\mu\text{m}$ . The pulse length was 12 ns, and the laser could operate either in the single-pulse mode or with a recurrence rate of 12 Hz. The thresholds of destruction were measured, and it was found that they decrease in the frequency mode for mirrors that have low reflectance for the wavelength of the laser emission. It is shown that the thresholds of destruction of both single-layer films of  $\text{TiO}_2$  and multilayer coatings of  $\text{TiO}_2$  and  $\text{SiO}_2$  are determined by the strength of the surface layers of the  $\text{TiO}_2$  films. Therefore the distribution of emission intensity in the  $\text{TiO}_2$  layers must be taken into consideration, and especially at the interfaces of these layers since they have the lowest thresholds of destruction. An examination is made of the influence that a change of intensity of emission on the boundaries of the  $\text{TiO}_2$  layers due to a shift in the spectral characteristic of the mirror relative to laser wavelength has on the threshold of destruction. Figures 3, references 9: 5 Russian, 4 Western.

USSR

UDC 535.375.5

CONCERNING THE LIMITS OF EXISTENCE OF THE EFFECT OF INVERSION OF THE WAVE FRONT THAT ACCOMPANIES STIMULATED SCATTERING OF LIGHT

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 36-43 manuscript received 1 Feb 77

ZEL'DOVICH, V. YA., and SHKUNOV, V. V., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Institute of Problems of Mechanics, Academy of Sciences of the USSR, Moscow

[Abstract] The authors consider the effect of inversion (or reproduction) of a wave front that is observed in pumping beams with strongly developed transverse interference structure. The essence of this effect is that when the intensity  $I_L(r,z) = |E_L(r,z)|^2$  of a stimulating wave  $E_L(r,z)$  is spatially nonhomogeneous in distribution, the maximum gain is shown by the transverse configurations of the scattered field  $E_S(r,z)$  for which the maxima of  $I_S(r,z)$  are matched with the maxima of  $I_L(r,z)$ . In the case of small difference between the wavelengths of the pumping waves and the scattered field, diffraction leads to improvement of reproduction. On the other hand, when the scattered field is pulled into the cores of diffraction filaments with high pumping intensity (coiled active micro-waveguides), reproduction is impaired, although the increment for the scattered field is increased. This "coiling effect" is analyzed by a power-series expansion of the power of monochromatic pumping with statistically nonhomogeneous transverse structure. The authors thank V. V. Ragul'skiy for useful discussion, and V. G. Sidorovich for calling their attention to his previous work. References 13 Russian.

USSR

UDC 621.378.3

SELECTION OF RADIATION IN POWERFUL ARGON LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 29-35 manuscript received 17 Jan 77

ALFEROV, G. N., GRIGOR'YEV, G. A. and LONIN, V. I., Institute of Physics of Semiconductors, Siberian Department of the Academy of Sciences USSR, Novosibirsk

[Abstract] An analysis is made of the possibilities of producing light fluxes with maximum power and minimum spectral width by using mode selection in argon lasers. Methods of isolating the TEM<sub>00</sub> mode in cw lasers with a large-aperture discharge tube are analyzed, and cavities

of three different configurations are experimentally studied. Single-frequency emission is achieved on line  $\lambda = 514.5$  nm with power of 20 W in an argon laser with a discharge tube 14 mm in diameter and active length of about 1.7 m with coefficient of conversion to the single-frequency mode  $\eta \approx 0.4$ . Design improvements should enable an increase in power output to more than 100 W. The main results of the research covered by this paper were reported to the Seventh All-Union Conference on Coherent and Nonlinear Optics in Tbilisi, May 1976. Figures 2, references 21: 12 Russian, 9 Western.

USSR

UDC 537.52

INVESTIGATION OF THE INFLUENCE THAT A HIGHLY-IONIZED CHANNEL PRODUCED BY A POWERFUL LASER HAS ON THE DEVELOPMENT OF A DISCHARGE IN A LONG AIR GAP

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 47, No 10, Oct 77  
pp 2122-2124 manuscript received 15 Jul 76

ALEKSANDROV, G. N., IVANOV, V. L., KADZOV, G. D., PARFENOV, V. A.,  
PAKHOMOV, L. N., PETRUN'KIN, V. YU., PODLEVSKIY, V. A. and SELEZNEV, YU.  
G., Leningrad Polytechnical Institute imeni M. I. Kalinin

[Abstract] An experimental study was done on the way that a highly ionized channel in air created by a high-power laser influences the development of a spark discharge across a 10-meter air gap with a strongly nonhomogeneous field when the voltage across it has a rise time of the order of 3500  $\mu$ s. In this case the discharge develops in leader form, in contrast to previous experiments in which the discharges have taken place in streamer form. It was found that the laser spark has a considerable influence on the direction of development of the discharge, which can be attributed to the formation of a space charge that distorts the field of the discharge gap. It is possible that the charges of the laser spark are spatially separated under the action of the electric field of the discharge gap. Estimates show that such charge separation occurs in a time shorter than the time of charge recombination in the laser spark. Figure 1, references 9: 6 Russian, 3 Western.

USSR

UDC 621.378.325:533.9

# EXTENDING THE DYNAMIC RANGE OF THE INTRACAVITY METHOD OF MEASURING OPTICAL DENSITIES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 13-19  
manuscript received 20 Dec 76

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[Abstract] The paper gives the results of a study of the analytical possibilities of a laser with a compound three-mirror cavity. These investigations covered the essence of the method and the corresponding analytical expressions, the feasibility of expanding the range of measurement of optical densities, conditions of calibrating the sensitivity of the cavity to insertion losses, and verification of the measurement technique on different objects. In the optical arrangement, the active element is located between two mirrors that form the main cavity, and the third mirror is located beyond the output mirror of the main cavity on the same optical axis to form an auxiliary cavity. The study specimen can be placed in either cavity. Registration of the intensity of laser emission is by a photomultiplier in combination with an electrometer voltmeter in the case of cw operation, or an oscilloscope in the case of pulsed emission. The studies were done with a cw He-Ne laser emitting on wavelengths of 632.8 and 1150.3 nm, and also with organic dye lasers. The results of the study show that the proposed compound cavity enables determination of optical losses in matter over a wide range of variation. Materials of comparatively high optical density can be used to calibrate losses in the cavity. The intracavity method of optical density measurement should be very useful for quantitative spectral analysis using dye lasers. Figures 4, references 11: 10 Russian, 1 Western.

USSR

UDC 621.378.325.4

# OPTICAL SPECTRA OF THE ACOUSTO-OPTICALLY MODE-LOCKED CW Nd:YAG LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian No 12, Dec 77 pp 2644-2646

KUBECEK, V., HAMAL, K., Nuclear and Physical-Technical Department, The University, Prague, Czechoslovakia

[Abstract] A study was made of the CW Nd:YAG laser using the Fabry-Perot interferometer. Mode locking was achieved using an acousto-optic modulator. Spectral bandwidth up to 4.8 GHz was obtained, corresponding to a pulse

length of 200 ps. The YAG:Nd rod was 7 mm in diameter and 75 mm in length; it was pumped by a krypton arc lamp placed in an elliptical reflector. The acousto-optical modulator was a block of fused quartz whose ends were cut at the Brewster's angle; a quartz converter was set on the lateral surface. The maximum output of HF oscillations of the quartz-stabilized oscillator was 3 watts at 75 MHz. The modulator was tuned by changing the temperature. Laser emission consisted of a pulse train with period of 6.7 ns having an average output of 0.3 W, i.e., an emission energy of 2 nJ/pulse. The length of the pulse measured with a stroboscopic oscillograph and type HP4220 photodiode was 410 ps. Figures 3; references 1: Western.

USSR

UDC 621.373.8

PULSE SHAPING BY SEPARATE EXCITATION OF DIFFERENT AREAS OF THE ACTIVE MEDIUM IN THE LASER RESONATOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian No 12, Dec 77 pp 2637-2641

DONNERHACKE, K. H., SCHIPALOW, A. S., SCHUBERT, M. and WIEDERHOLD, G.,  
F. Schiller University, Jena, DDR

[Abstract] A new excitation method is proposed for shaping and lengthening the output pulse of the TEA carbon dioxide laser. It is based on the independent excitation of two or more axial discharge systems in the same resonator. Based on equations of equilibrium, calculations were made on the shape of the TEA carbon dioxide laser pulse with respect to the delay time between two exciting current pulses. This report presents the first experimental results of laser tests. Figures 5; references 12: 3 Russian, 9 Western.

USSR

UDC 621.378.33

ON THE POSSIBILITY OF  $I^{127}$  AND  $I^{129}$  ISOTOPIC SEPARATION USING A PHOTODISSOCIATION IODINE LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian No 12, Dec 77 pp 2628-2632

ANDREYEVA, T. L., KUZNETSOVA, S. V., MASLOV, A. I., SOBEL'MAN, I. I. and YUKOV, YE. A., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] A method is proposed for iodine isotope separation based on the large difference between the rate constants for reactions between the excited  $I^*(^2P_{1/2})$  or unexcited  $I(^2P_{3/2})$  iodine atoms and  $CF_3$  radicals or  $Cl_2$  molecules and on the feasibility of selectively affecting the  $I^{127}$  atoms in the  $^2P_{1/2}$  and  $^2P_{3/2}$  states by radiation from a photodissociation iodine laser using  $R^{127}I$  molecules (wavelength 1.315 microns). A procedure is discussed for pure  $I^{129}$  isotope separation from the mixture of  $I^{127}$  and  $I^{129}$ . Increasing the coefficient of concentration one degree to 3-5 is only possible with a large excess of radicals. Figures 2; references 15: 10 Russian, 5 Western.

USSR

UDC 621.378.33

STUDIES INTO GLASS CUTTING WITH THE USE OF A  $CO_2$  LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian No 12, Dec 77 pp 2609-2610

SCHIFFER, F., ZIERMANN, R., F. Schiller University, Jena, DDR

[Abstract] Studies of interaction between a laser beam and material showed characteristic damage in various areas: in one area due to ejection of matter and in another area due to thermomechanical effects. Mechanical glass cutting is done by mechanical forces (breaking), thermal impact (heating and sudden cooling), and diamond cutting. The accuracy and economics of laser cutting should be greater than mechanical methods. A carbon dioxide laser has good technical possibilities. Laser output is the primary parameter to determine minimum cutting time. High accuracy and quality of cutting can be attained regardless of stresses occurring in a tubular item. Figures 1; references 5: 1 Russian, 4 Western.

USSR

UDC 535.565

#### RAMAN INDUCED KERR EFFECT IN SINGLE CRYSTALS

Moscow KVANTOVAYA ELEKTRONIKA in Russian No 12, Dec 77 pp 2570-2574

BERGMANN, J., KNEIPP, K. and PONATH, H. E., F. Schiller University, Jena, DDR

[Abstract] The first experimental and theoretical investigation of the Raman induced Kerr effect (RIKE) in crystals are reported. Using a Stokes continuum within the range of 725-740 nm in the RIKE spectrum of the  $\text{LiIO}_3$  crystal an A(LO) oscillation was found at  $817 \text{ cm}^{-1}$ . General equations of RIKE in noncentrosymmetric uniaxial crystals have been derived to describe the steady-state effect, considering an induced polariton field and possible occurrence of optical activity. In addition, a transient probe beam method is discussed for analysis of transverse relaxation time  $T_2$ : it is compared with a similar method in coherent anti-Stokes Raman scattering. Figures 2; references 6: all Western.

USSR

UDC 535.14

#### QUANTUM STATISTICAL PROPERTIES OF OPTICAL PARAMETRIC PROCESSES

Moscow KVANTOVAYA ELEKTRONIKA in Russian No 12, Dec 77 pp 2552-2555

MISTA, L., PERINA, J. and PERINOVA, V., Optics Laboratory, Palack University, Olomouc, Czechoslovakia

[Abstract] Attention has recently been directed at so-called anticorrelation effects which lead to variation of emission which is less than in the coherent state. These effects can be generalized to nondegenerate processes: there is a time dependence of photon statistics in the anticorrelation mode. This may be so with classical and quantum pumping. The time behavior of photon statistics under anticorrelation conditions produces a reduction in ambiguity (quantum noise) versus the coherent state. Figures 3; references 8:2 Czech, 6 Western.



USSR

UDC 621.378.4

# OPTIMAL FOCUSING IN A SINGLE-CAVITY PARAMETRIC LIGHT OSCILLATOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian No 12, Dec 77 pp 2547-2552

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[Abstract] Parametric light oscillators are tunable lasers primarily for the near and middle spectral regions. The spectral properties of emission generated by parametric light oscillators (PLO) depends greatly on the type of feedback used. PLOs with a resonator tuned to a single wave are best. The possible implementation of a continuous uniresonator PLO requires resolution of the problem of optimum focusing: defining the conditions of focusing at which the output of the pumping wave required to generate emission is minimum. This is the first discussion of optimum focusing for single-cavity PLO, except for spherical resonators without consideration of double refraction. A reduction of threshold power in double refraction may be achieved in two ways: by elliptical focusing of pumping emission or by optimum selection of a confocal parameter for the signal wave and pumping wave. It is possible that threshold power will drop enough in the presence of double refraction that a continuous uniresonator PLO will become possible. Figures 6; tables 1; references 8: 3 Russian, 4 Western.

USSR

UDC 535.41+621.375.826

# UNIVERSAL METHOD FOR TRANSFORMATION OF LASER FIELDS WITH COMPLEX TRANSVERSE MODE STRUCTURE

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian No 2, Feb 78 pp 311-317  
manuscript received 2 Sep 77

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[Abstract] Most lasers have a transverse mode structure which gives rise to divergence of the laser beam and comparatively low spatial coherence of the light field through the cross section of the beam. Existing methods employ holographic correction of the wavefront of coherent laser fields. But this method has its shortcomings: the modal structure must be stationary and the field must have high spatial coherence. A new correction system consists of two elements: wavefront modulator with coefficient of transmission described herein and the corresponding

hologram. This makes it possible to shape a laser beam with a deltoid distribution of intensity in the angular spectrum which is practically independent of the transverse mode structure of the laser emission. This method is universal for different fields, including those with a low degree of spatial coherence. Figures 6; references 6: all Russian.

USSR

UDC 621.378.325

SEPARATION OF FLUID MIXTURES IN THIN FILMS BY THERMAL ACTION OF LASER RADIATION

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78 pp 833-837 manuscript received 28 Mar 77

KRINDACH, D. P., MAYOROV, V. S., and SHELUKHOV, I. P., Institute of Physics, Moscow State University imeni M. V. Lomonosov

[Abstract] Nonuniform heating of a fluid mixture by laser radiation can cause a separation of the components. The mechanism of this process is analyzed here for an ideal initially homogeneous binary mixture inside a translucent closed vessel. Calculations are based on the equations of concentration, surface tension and continuity in a nonuniform temperature field. Experimental data on the process kinetics in such real mixtures as acetone solutions of iodine and acetone solutions of furfural have established the feasibility of partition or purification of substances with an argon laser. The authors thank R. V. Khokhlov for the supportive interest in this study, also Ye. A. Galashin and B. A. Bezuglyy for the helpful discussion. Figures 4; references: 3 Russian.

USSR

UDC 621.373.826

MEASUREMENT OF THE FOUR-POINT FIELD COHERENCE FUNCTION WITHIN THE REGION OF RANDOM FOCUSING OF LASER RADIATION

Gor'kiy IZVESTIYA VUZOU RADIOFIZIKA in Russian Vol 21, No 3, Mar 78 pp 398-407 manuscript received 29 Oct 76

GURVICH, A. S. and KAN, V., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] The four-point field coherence function of laser radiation was measured within the region of random focusing, i.e., of maximum light

intensity surging and fading in a turbulent and locally isotropic medium. The theory of this measurement is based on second-order and fourth-order coherence functions of a plane wave and applied to an array of points forming a parallelogram (rectangle). The measurements were made with a wide collimated beam from an He-Ne laser operating at the  $0.63 \mu\text{m}$  wavelength, turbulence being produced in a water layer between two horizontal heat exchangers inside a 35 cm long vessel. Reliefs were then plotted representing the dependence of this function on the distance between points. The results are compared with and found to differ somewhat from theoretical results based on a normal distribution of the complex field phase or based on the smooth-perturbations approximation. The authors thank V. I. Tatarskiy for discussion and helpful comments. Figures 3; references 10: 9 Russian, 1 Western.

USSR

UDC 537.311.33:621.375.82:621.375.9

# REMOVAL OF LASER BEAM DISTORTIONS INDUCED IN AMPLIFIERS BY METHODS OF DYNAMIC HOLOGRAPHY

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 23, No 4, Apr 78  
pp 562-567

ODULOV, S. G. SAL'KOVA, YE. N., SOSKIN, M. S., and SUKHOVERKHOVA, L. G.,  
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[Abstract] An experimental study has established the feasibility of using dynamic holography for correcting dynamic distortions of a laser wave front within the active medium of a laser amplifier. The principle is based on producing a wave with complex-conjugate distortions by the holographic grating. The relaxation time of processes in the hologram recording medium must be shorter than the time within which the wave front changes. The complex-conjugate wave must, furthermore, exactly duplicate the complex-conjugate wave front so that the front of the reference wave remains invariable throughout the transformation process. The experiment used a ruby laser emitting 1 MW pulses of 70 ns duration, a CdS crystal for recording the hologram, and an alcohol solution of kryptocyanine or a ruby rod as the nonlinear distorting medium. The method appears suitable for high-gain systems. The authors thank E. V. Markov for supplying the CdS crystals. Figures 5; references 11: 9 Russian, 2 Western.

## DYNAMIC THEORY OF THE SPIKE MODE IN RUBY LASERS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 44, No 4, Apr 78 pp 766-770 manuscript received 10 Aug 77

GAYNER, A. V., KOMAROV, K. P., and FOLIN, K. G.

[Abstract] In order to explain the spike mode of emission in solid-state lasers, where damping of pulsations is a rather slow process, experimental data are phenomenologically interpreted here in terms of an additional interaction between modes. Two-mode interaction is analyzed on the basis of nonlinear polarizability of the active medium, the polarization being proportional to the electric field intensity cubed. The effect of this interaction is shown to be suppression of the weak mode with a strong mode present, in the case of fast relaxation from the lower emission level to the intermediate level or fast exchange between the intermediate level and the upper emission level, resulting in undamped spikes due to alternation of modes. No such suppression and resulting effect occur when the relaxation or exchange time is long. References 15: 11 Russian, 4 Western.

USSR

UDC 533.95:538.65

## TIME OF DEVELOPMENT OF MHD PINCH INSTABILITY OF LIQUID CONDUCTORS IN AN INTRINSIC CURRENT FIELD

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 47, No 10, Oct 77  
pp 2116-2121 manuscript received 21 Jun 76

LEV, M. L. and PERGUD, B. P.

[Abstract] The stability of solutions of a system of MHD equations is studied by the method of small perturbations for the axially symmetric case (wave number  $m = 0$ , pinch effect). It is shown that the theoretical time necessary for an increase in the amplitude of an arbitrary instability to a predetermined amplitude  $\xi$  is  $t_{th} = \tau \ln \xi / \xi_0$ , where  $\tau = 1/\omega$  is the time constant of development of the instability, and  $\xi_0$  is the amplitude of the initial perturbation. Exploding-wire experiments are done with eight different metals with a wide variety of properties. The oscillograms are analyzed by a method in which the zero of time is determined at the point where the metal is first in the molten state. Comparison of the experimental results with the theoretical predictions shows that the existing MHD theory gives a good quantitative description of the process of destruction of liquid conductors by an intrinsic current field, and can reliably predict not only the modes and wavelengths of developing instabilities, but also the time of existence of the liquid conductor as high-density electric current flows through it. Figures 2, references 16: 13 Russian, 3 Western.

USSR

UDC 538.4

## SHUNTING RATIOS FOR MHD FLOWS

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 83-89  
manuscript received 23 May 77

BIRZVALK, YU.

[Abstract] The shunting ratio and the local shunting ratio, pertaining to currents induced by a magnetic field in a flow channel, are properly defined and systematically reviewed on the basis of the Lagrange criterion. Their definition is based on the energy balance and related to dimensionless parameters characterizing an MHD flow, these parameters evolving from the Hartmann number and the hydrodynamic Reynolds number as well as the magnetic Reynolds number and the Lundquist number. These shunting ratios, of current density in the core of a stream (uniform) or equivalent mean current density to the short-circuit (maximum) current density, are given

here for a slot channel with nonconducting or conducting walls, for a conduction channel with heavy side rails, and for an MHD-flow around bodies. The author thanks D.S. Konev for suggesting the use of the Lagrange criterion, also E.Ya. Blum and E.V. Shcherbin for the valuable comments. Figures 1; references 5: 4 Russian, 1 Western.

USSR

UDC 621.313.333:538.4

TWO-DIMENSIONAL DESCRIPTION OF THE ELECTROMAGNETIC AND THE LONGITUDINAL  
EDGE EFFECT IN A CHANNEL OF AN MHD CONDUCTION PUMP WITH A CLOSING RAIL

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No. 1, Jan-Mar 78 pp 100-112  
manuscript received 18 Feb 77; after revision, 18 Jun 77

BRAYNIN, M. I.

[Abstract] The distribution of the electromagnetic field over the length and the width of a flat channel of an MHD conduction pump with a closing rail is treated as a two-dimensional problem, and from its solution are derived analytical expressions for calculating the basic energy parameters of channel performance: dimensionless pressure drop, efficiency, and edge-effect loss factor. The closing rail is assumed to be an ideal conductor and longitudinal currents within the active zone to be due to the presence of a passive zone. The integral equation describing the distribution of magnetic induction in the active zone is derived from the fundamental field equation for a moving and conducting medium. This equation is now solved by the method of successive approximations and subsequent conformal mapping. The results are valid within an accuracy of the order of  $O(\xi^2)$ , with  $2\xi$  denoting the channel width. Figures 1; references 4: 3 Russian, 1 Western.

USSR

UDC 538.4

TRANSIENT FLOW OF A CONDUCTING FLUID THROUGH A HALF-SPACE AND THROUGH A  
FLAT CHANNEL IN A NONUNIFORM EXTERNAL MAGNETIC FIELD

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No. 1, Jan-Mar 78 pp 59-65  
manuscript received 15 May 77

ANTIMIROV, M. YA.

[Abstract] The transient flow of a conducting fluid in a nonuniform magnetic field is analyzed with consideration of the edge effect and in the zero-inductance (zero Prandtl number) approximation. The magnetic field induced by surface currents, first in only one thin wall and then in two thin walls, is calculated - with the current density described in terms of the delta function. The results of the general solution are then applied to flow through a half-space and through a flat channel under a pressure gradient respectively. With the appropriate boundary conditions, Couette flow is considered as a special case. References 8: 4 Russian, 1 German, 3 Western.

USSR

UDC 532.51:538.3:538.4

EQUILIBRIUM OF A LIQUID DIELECTRIC WITH A FREE BOUNDARY BETWEEN TWO  
CHARGED NONCONCENTRIC SPHERES

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 90-94  
manuscript received 7 Feb 77

IYEVLEV, I. I.

[Abstract] A vessel is formed by two spheres, one nonconcentrically inside the other, and filled with two immiscible liquid dielectrics. Both dielectrics are assumed to be homogeneous and isotropic, each having a different density and a different permittivity. The behavior of this system of dielectrics, with surface tension at their boundary, in an external gravitational field as well as the electric field due to charges on the spherical vessel surfaces is analyzed on the basis of the fundamental differential equation of equilibrium in spherical coordinates. The stability of equilibrium is determined according to the sign of the smallest eigenvalue for this boundary-value problem and the stability limit is found, correspondingly, to depend on the configuration. Figures 1; references 2: 1 Russian, 1 Western.

USSR

UDC 621.371.32:621.313.333:538.311:538.4

ACCURACY OF THE DIPOLE APPROXIMATION OF EXTERNAL ELECTROMAGNETIC FIELDS  
OF MHD MACHINES

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 146-148  
manuscript received 14 Feb 77

APOLLONSKIY, S. M.

[Abstract] For the design of shielding shells around electric sources such as elements of MHD machines, one mathematically simulates the field of individual source elements with dipoles. The latter are each uniquely defined by six parameters: components of its moment along three coordinate axes and three coordinates of its center. The accuracy of such an approximation is evaluated here and found to depend on the distance  $R$  from the source relative to the effective diameter  $d$  of the latter. At distances  $R \geq 10d$  one central dipole is sufficient, at distances  $R \leq 5d$  an array of arbitrarily oriented and spaced dipoles is necessary, and at intermediate distances several central arbitrarily oriented dipoles are adequate. References: 4 Russian.

USSR

UDC 533.951.3

ON LOCAL MHD STABILITY OF EQUILIBRIUM PLASMA CONFIGURATIONS

Leningrad ZHURNAL TEKHNIKESKOY FIZIKI in Russian Vol 48, No 1, Jan 78  
pp 21-24 manuscript received 18 Oct 76

SOLOV'YEV, L. S.

[Abstract] The author considers the potential energy of perturbations for a plasma in a magnetic field, assuming that the perturbations are localized in a thin layer in the vicinity of the magnetic surface with closed lines of force. A necessary stability criterion is derived for equilibrium plasma configurations of arbitrary geometry. In the case of a low ratio of the speed of sound to the Alfvén velocity this criterion becomes identical to the Mercier criterion, and in the case of vanishingly small shear it is transformed to the Spies criterion [G. O. Spies, "Physics of Fluids," Vol 17, No 2, 1974]. The proposed criterion relaxes restrictions on the equilibrium configuration parameters in the region of low shear as compared with the Mercier criterion. An approximate expression is given for the criterion in the case of a toroidal configuration with low curvature of the magnetic axis. References 11: 6 Russian, 5 Western.



USSR

UDC 538.4

# BREAKUP OF A LIQUID-METAL JET IN A MAGNETIC FIELD

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 137-140  
manuscript received 23 Mar 77

VASIL'YEV, M. N.

[Abstract] A jet of liquid discharged into a gaseous medium is unstable under small perturbations and, at some distance from the orifice, it breaks up into droplets. A magnetic field can, in the case of an electrically conducting liquid, significantly affect the breakup characteristics of such a jet. Here an experimental study was done with a jet of 62% Ga - 25% In - 13% Sn alloy, melting at  $+10.5^{\circ}\text{C}$ , in a longitudinal magnetic field. The dependence of the breakup distance and of the mist spread angle on the density of the ambient gas was found to be affected by the magnitude of the magnetic induction and of the inertia forces, so that an evaluation in terms of the Stewart number is appropriate. The results indicate that a longitudinal magnetic field increases the stability of a cylindrical jet and narrows the spread of the mist. The author thanks A. S. Koroteyev for guidance and I. N. Rey for help in setting up the experiment. Figures 6; references 6: 5 Russian, 1 Western.

USSR

UDC 538.4

# OPTIMUM PERFORMANCE CHARACTERISTICS OF A CONDUCTION CHANNEL

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 125-131  
manuscript received 24 Aug 77

OKULOV, N. A.

[Abstract] Steady laminar flow of an incompressible viscous and electrically conducting fluid is considered in an infinitely long cylindrical conduction channel. A set of permanent magnets outside produces a transverse magnetic field which does not vary over the channel length. An external electric d.c. generator or load maintains on the channel-fluid boundary a distribution of electric potential which also does not vary over the channel length. The power efficiency of such a channel is calculated and the distribution of electric potential is then optimized to yield the maximum efficiency for a given pressure head and flow rate, with a given scalar magnetic potential. Two mathematical theorems are proved for solving the optimization problem, i.e., the problem of minimizing a functional. An upper estimate of the efficiency is made on the basis

of a third theorem. An estimate is also made of the flow rate in a conduction channel with a passive electrical system (load without generator). Figures 1; references: 3 Russian.

USSR

UDC 533.95

ON INCREASING THE NEUTRAL GAS IN AN RF DISCHARGE PLASMA WITH A ROTATING MAGNETIC FIELD

Leningrad ZHURNAL TEKHNIKESKOY FIZIKI in Russian Vol 48, No 1, Jan 78  
pp 66-71 manuscript received 24 Dec 76

AVERIN, V. G., BELORUSOV, A. V., KARCHEVSKIY, A. I., MARTSYNK'YAN, V. L.,  
POPOV, I. A. and POTANIN, YE. P.

[Abstract] An experimental study is done on the parameters of an rf discharge with rotating magnetic field of dipole configuration to determine the feasibility of using such a system for isotope separation. The rotational velocity of the magnetic field is of the order of  $10^7$  Hz in a cylindrical chamber 120 cm long and 8 cm in inside diameter. The glass working chamber was positioned vertically, the working gas was xenon and the investigated range of initial pressures was  $10^{-1}$ - $10^{-2}$  mm Hg. The power dissipated in the plasma was 0.3-2 kW. It is shown that the peripheral velocity of neutral atoms in the investigated region of discharge parameters does not exceed a few thousand cm/s. Theoretical estimates are made of the average mass flow of plasma rotation and the expected centrifugal effects as applied to isotope mixtures of Xe, and an examination is also made of possible ways to improve the effectiveness of isotope separation in such systems. Figure 1, references 11: 7 Russian, 4 Western.

USSR

UDC 533.95

INVESTIGATION OF THE PARAMETERS OF A MAGNETIZED FLOW OF SYNTHESIZED PLASMA

Leningrad ZHURNAL TEKHNIKESKOY FIZIKI in Russian Vol 48, No 1, Jan 78  
pp 49-56 manuscript received 28 Dec 76, after final revision 22 May 77

NOSACHEV, L. V. and SKVORTSOV, V. V., Central Aerohydrodynamics Institute  
imeni N. Ye. Zhukovskiy, in Zhukovskiy

[Abstract] Experiments are done on effects that arise in the vicinity of bodies in a flow of rarefied plasma. A facility is used in which a synthesized plasma flow is produced by a gas-discharge ion source, the ion space charge being neutralized by electrons emitted by a special neutralizer. The working gas is helium, and the synthesized plasma flows in an external longitudinal magnetic field. Analysis of the flow characteristics shows that the proposed technique can be used to simulate ionospheric conditions for laboratory aerodynamic studies. Figures 5, references 14: 11 Russian, 3 Western.

USSR

UDC 533.538.4

MODEL PROBLEM OF MHD FLOW IN A LITHIUM BLANKET

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 117-120  
manuscript received 24 Feb 77

CHEREpanov, V. YU.

[Abstract] A model problem is considered for a feasibility study concerning controlled MHD flow in the blanket of a "Tokamak" nuclear reactor. The fundamental equations for the steady flow of an incompressible viscous fluid in a uniform transverse magnetic field are solved in rectangular coordinates, in the zero-induction approximation and with negligible induced currents. A numerical solution obtained for a set of appropriate boundary constraints establishes the conditions under which no stagnation zones will be formed. The author thanks E. V. Shcherbinin and Kh. E. Kalis for helpful discussion. Figures 6; references: 4 Russian

USSR

UDC 621.313.333:538.4

#### EFFECTIVENESS OF SIDE RAILS IN MHD LINEAR INDUCTION MACHINES

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 113-116  
manuscript received 29 Nov 76

PARTS, L. R.

[Abstract] The effectiveness of using side rails in MHD linear induction machines depends on their geometric dimensions, on the electrical conductivity of their material, on the intensity of the primary magnetic field at their location, and on the slip. It is shown here that side rails can sometimes lower rather than raise the machine efficiency. The force attenuation factor is used as the performance criterion and calculated for various typical values of the magnetic Reynolds number and the electrical conductivity at slip  $s = 1$ , with and without side rails. The results indicate that side rails reduce the electromagnetic forces and their use is not worthwhile, if their presence decreases the force attenuation factor. The effect of including or disregarding the inductance of side rails in the calculations is also evaluated. Figures 1; tables 1; references: 6 Russian.

USSR

#### ALFVEN AND MAGNETOACOUSTIC VORTEX FLOWS IN A PLASMA

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 73 No 2(8), Aug 77 pp 498-505 manuscript received 17 Jan 77

PETVIASHVILI, V. I. and POKHOTILOV, O. A., Institute of Physics of the Earth imeni O. Yu. Shmidt, Academy of Sciences USSR

[Abstract] The authors consider propagation of Alfven and magnetoacoustic vortices in a low-pressure plasma ( $\beta \approx 8\pi p/H_0^2 \ll 1$ , where  $p$  is the plasma pressure,  $H_0$  is the undisturbed magnetic field). The analysis is facilitated by the presence of small parameters, which reduces the equations of magnetohydrodynamics to simpler equations of nonhomogeneous solitons by means of the theory of perturbations, taking the dispersion terms and nonlinear terms as small quantities of one order of magnitude (an expansion of the Korteweg-de Vries type). It is shown that dispersal of two-dimensional and three-dimensional MHD vortices of the type considered is checked by nonlinear effects. The magnetoacoustic waves form a toroidal vortex that travels along the magnetic field at the Alfven velocity. The nonlinear Alfven waves form an axially symmetric waveguide

along the magnetic field. Inside the waveguide, the plasma undergoes vortex oscillations in the azimuthal direction. Such MHD vortices are observed in the magnetosphere of the earth. The authors thank A. B. Mikhaylovskiy for advice and discussion of the work. References 17: 12 Russian, 5 Western.

USSR

UDC 532.517.4:538.4

NUMERICAL ANALYSIS OF THE AVERAGE MHD FLOW WITHIN A CYLINDRICAL REGION ON THE BASIS OF APPLICABLE HYPOTHESES ABOUT TURBULENT STRESSES

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 51-58 manuscript received 14 Jun 77

MIKEL'SON, YU. YA., YAKOVICH, A. T., and PAVLOV, S. I.

[Abstract] Turbulent stresses are considered in an incompressible fluid due to MHD flow induced within an axisymmetric region by electromagnetic forces on the basis of the linearized equation of motion as well as on the basis of the stress tensor in terms of average velocities and turbulent viscosity. The turbulent viscosity is treated according to the Boussinesq hypothesis (constant turbulent viscosity), according to the generalized Karman hypothesis (turbulent viscosity a function of the derivatives of the velocity components with respect to the respective coordinates), or as the product of its coordinate functions. The results of numerical calculations indicate a close agreement between all these formulas for an average MHD flow and experimental data. Calculations including this additional "turbulent" force, appropriately related to the flow parameters, are applicable to the design of liquid-metal devices. Figures 3; references 7: 6 Russian, 1 Western.

USSR

UDC 538.4:538.114

EXPERIMENTAL STUDY OF BUOYANCY OF MAGNETIC BODIES IN A MAGNETIZABLE FLUID

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 23-27 manuscript received 1 Jun 77

BARKOV, YU. D. and FERTMAN, V. YE.

[Abstract] An experimental study was made of forces acting on a magnetic body in a magnetizable fluid. A permanent magnet of barium ferrite, in

the shape of a parallelepiped and with a vertical magnetic orientation, was immersed in a fluid magnetizable by a field of  $6.74 \cdot 10^4$  A/m intensity at the center of the horizontal magnet surface. The force balance and the resultant buoyance effect are now analyzed on the basis of experimental data and a mathematical model involving the MHD extension of Bernoulli's equation. The stiffness of such a solid-fluid system is also evaluated, with a view to practical applications. Figures 3; references 7: 3 Russian, 4 Western.

USSR

UDC 537.523

#### RADIAL CONSTRAINT ON THE FOCAL ZONE IN A MAGNETIC PLASMA COMPRESSOR

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16, No 2, Mar-Apr 78 pp 268-273 manuscript received 10 Mar 77

KAMRUKOV, A. S., KOZLOV, N. P., and PROTASOV, YU. S., Moscow Higher Technical School imeni N. E. Bauman

[Abstract] A study was made to determine the feasibility of localizing the plasma focus inside an erosion-type magnetic compressor by means of transparent walls. Open and radially constrained discharges in CsI and in  $C_2F_4$  were triggered from a capacitor bank through a low-power plasma injector. Their structure and dynamic characteristics were analyzed, especially over the first few half-periods, with the aid of a high-speed photorecorder. The radiation power from a radially constrained discharge at visible and ultraviolet wavelengths was found to be an almost cubic function of the ignition voltage and, therefore, the luminous efficiency to be an almost linear function of the stored electric energy. Radial constraint of a focused plasmodynamic discharge can thus be used for producing a high-intensity source of light and near-ultraviolet radiation. Figures 4; references: 10 Russian.

USSR

UDC 621.313.12:538.4

# CONSTRUCTION OF A MATHEMATICAL MODEL FOR THE INTERELECTRODE FLASHOVER IN AN MHD GENERATOR

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16, No 2, Mar-Apr 78 pp 435-437 manuscript received 9 Jun 77

POBEREZHSKIY, L. P., All-Union Scientific Research and Planning Institute for Progress in Transportation

[Abstract] The performance of an open-loop MHD generator, namely its energy conversion efficiency as well as reliability and overload capacity, is largely determined by the electrode processes. Interelectrode flashover and Hall current leakage during arc discharge are particularly important. A mathematical model on the basis of Thevenin's theorem is constructed here for analyzing these phenomena and calculating the breakdown voltage in a low-power generator ( $r_{input} \gg r_{arc}$ ) and in a high-power generator ( $r_{input} \ll r_{arc}$ ), with the arc resistance  $r_{arc}$  depending on the arc dimensions as well as on the temperature excess and the heat flow balance. The calculations are referred to an equivalent electric circuit with two electrode pairs and a resistance between the two anodes. The author thanks A. V. Nedospasov for interest and helpful discussion. Figures 2; references 19: 16 Russian, 3 Western.

USSR

UDC 538.3:532.516.2:538.4

# AN EHD LUBRICATING LAYER

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 95-99 manuscript received 20 Jun 77

SHVARTS, I. A.

[Abstract] The simplest model of an EHD lubricating layer consists of a unipolarly charged nonconducting viscous fluid between two parallel or slightly inclined nonconducting plates. The performance of such a layer is analyzed here on the basis of the fundamental EHD equations, with a plane-parallel approximation of the flow of a thin layer under a variable upper boundary. The results of the solution indicate that the bearing capacity of such a layer between parallel plates does not depend on the viscosity of the fluid, but is proportional to the energy density of the electric field in vacuo. With the plates not parallel, the bearing capacity depends on the mobility and the diffusion of the charged fluid particles. In either case the energy of the electric field can be made

to compensate the energy dissipation due to viscous friction, and in this case or with overcompensation such an EHD bearing becomes an EHD generator. Most valuable for practical applications are fluids with a high dielectric permittivity, such as ammonia and hydrogen chloride at cryogenic temperatures. Figures 1; references 5: 4 Russian, 1 German.

USSR

UDC 533.951

PARAMETRIC INSTABILITY OF LONGITUDINAL OSCILLATIONS OF A MAGNETICALLY ACTIVE PLASMA IN A TRANSVERSE-LONGITUDINAL FIELD GENERATED BY A HIGH-FREQUENCY WAVE

Gor'kiy IZVESTIYA VUZON, RADIOFIZIKA in Russian Vol 21, No 3, Mar 78 pp 326-332 manuscript received 27 Oct 76

ZUNDER, D., Central Institute of Electron Physics, GDR Academy of Sciences, Berlin, TSKHAKAYA, D. D., Institute of Physics, Academy of Sciences of the Georgian SSR

[Abstract] Potential oscillations in a magnetically active plasma are considered and the theory of their parametric instability due to the pumping field of an rf wave or two microwaves is further developed. In the linear one-dimensional case perturbations are small and all parameters characterizing them vary along one coordinate only. The analysis is based on the Maxwell field equations and the equations of plasma hydrodynamics. This system of equations, linearized into one with periodic coefficients, has a solution which yields the dispersion relation and the conditions of resonance. Only the longitudinal oscillations propagating normally to the direction of the electric field of the transverse wave are found to become unstable. Dissipation effects determine the instability threshold. References: 4 Russian.



USSR

UDC 621.313.12:538.4

#### EQUIVALENT ELECTRIC CIRCUIT OF A DIAGONAL-CHANNEL MHD GENERATOR

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16, No 2, Mar-Apr 78 pp 431-435 manuscript received 12 Oct 77

PAKHOMOV, YE. P. and SHABASHOV, V. I., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] The segmental electrodes of an MHD generator can be externally connected so as to form a diagonal channel. The performance of such a device is best analyzed on the basis of its equivalent circuit, with the load resistance as the only variable. Accordingly, the potential profile along the channel walls acting as electrodes is shown and compared with the potential profile in the same channel but with the electrodes connected into either a Faraday or a Hall generator. Also shown is the dependence of the electrode current on the load current per electrode, both referred to the short-circuit current, for all three modes of operation. The equivalent circuit of a diagonal channel, simplified by omission of the end segments, is drawn in the two-dimensional as well as in the three-dimensional version. The authors thank E. I. Asinovskiy and S. A. Medin for helpful discussion. Figures 4.

USSR

UDC 538.4

#### MHD ROTATION OF ELECTRICALLY CONDUCTING MEDIA IN CROSSED FIELDS

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 73-82 manuscript received 13 May 77

NIKITIN, N. V.

[Abstract] A nonlinear scheme is developed for calculating the hydrodynamic characteristics of MHD flow in a cylindrical vessel of finite dimensions, in an electric field and a magnetic field crossing each other. The incompressible fluid is assumed to have a constant viscosity and electrical conductivity. The solution to the complete system of MHD equations is expanded in a series with respect to the magnetic Reynolds number, for a large hydrodynamic Reynolds number, and rather simple engineering formulas for calculating the velocity field and the pressure field are derived by the Karman-Pohlhausen method of integral relations. The results are compared with experimental data pertaining to a model helium-xenon discharge chamber with distribution of the Lorentz force causing the plasma to rotate as a quasi-solid. The author thanks

L. P. Gorbachev for helping in every aspect of this study and discussing the results. Figures 5; tables 1; references 15: 7 Russian, 2 German, 6 Western.

USSR

UDC 538.4

VELOCITY FIELD OF STREAMS IN NONUNIFORM CONSTANT MAGNETIC FIELDS, PART  
1: NUMERICAL CALCULATIONS

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 66-72 manuscript received 29 Jun 77

GEL'FGAT, YU. M., PETERSON, D. YE., and SHCHERBININ, E. V.

[Abstract] Steady flow of a conducting fluid through a rectangular pipe in nonuniform magnetic fields of various configurations is analyzed and the results are found to depend on whether the magnetic field is assumed to have only a transverse or also a longitudinal component. Velocity and potential profiles are calculated numerically for each case, according to grids with various step sizes, also for an asymmetrically nonuniform and for a periodically nonuniform magnetic field. The feasibility of establishing practically any desired flow pattern by tailoring the magnetic field has thus been established, but the success of this procedure depends largely on the choice of the computation scheme and on the accuracy of computations, as well as on the assumptions made concerning the distribution of the magnetic field. Figures 6; references 9: 8 Russian, 1 Western.

USSR

DETERMINATION OF PLASMA TEMPERATURE FROM CIRCULATION ABSORPTION IN A  
NON-HOMOGENEOUS MAGNETIC FIELD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 73, No 2(8), Aug 77 pp 526-536 manuscript received 11 Feb 77

SKOVORODA, A. A., TIMOFEYEV, A. V. and SHVILKIN, B. N., Moscow State University imeni M. V. Lomonosov

[Abstract] The method of determining plasma temperature from Doppler broadening of the cyclotron absorption line is applicable where the

magnetic field is weakly nonhomogeneous and the change in cyclotron frequency is small compared with the Doppler shift. As a rule, the cyclotron frequency is much greater than the Doppler shift in systems of magnetic plasma containment. In this case the coefficient of absorption is independent of the electron temperature, and is determined by the magnetic field gradient and the plasma density. In this paper it is shown that if the magnetic field within the confines of the system has an extremum, the coefficient of absorption of oscillations with frequency close to the extremum cyclotron frequency is appreciably dependent on the electron temperature. Thus one can find the plasma temperature from measurements of the coefficient of absorption. The proposed method is experimentally verified on the simplest plasma object -- a gas-discharge plasma. The results agree well with the figure given by the probe method. It is suggested that the technique might be applicable to thermonuclear systems. Figures 6, references 12: 9 Russian, 3 Western.

USSR

UDC 538.4

#### MHD-EFFECTS IN A TURBULENT MEDIUM OF NONUNIFORM DENSITY

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 45-50  
manuscript received 12 Jul 77

VAYNSHTEYN, S. I.

[Abstract] Turbulence in a medium of nonuniform density, such as the convective solar layer, is analyzed with the assumption that  $\nabla \rho = \rho \lambda$  (exponential stratification). Considered are first the simplest case of a quasi-isotropic turbulence, then addition of a scalar factor such as the temperature, and finally anisotropic turbulence. The magnetic field and MHD-effects are then calculated without diffusion, and with two-dimensional turbulence as a special case. Also the values of the essential parameters in this problem are estimated. References 7: 5 Russian, 1 Western.

USSR

UDC 538.4:536.25

MHD-CONVECTION IN A PLANE HORIZONTAL LAYER WITH SURFACE TENSION

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 42-44  
manuscript received 12 May 77

LIYEPINYA, V. R.

[Abstract] The relation between critical values of the Marangoni number, the Rayleigh number, and the Hartmann number, expressed in terms of series whose convergence becomes slower with higher values of the Hartmann number, is extended to the case of thermal contact without perturbations between a horizontal layer of fluid and a solid heat conductor of finite thickness underneath. Heat transfer at the free upper boundary of this layer occurs according to Newton's law, and the boundary conditions here take into account surface tension as well as its temperature dependence. The limits of monotonic instability in a magnetic field are calculated from a numerical solution to this problem. Figures 1; tables 1; references 5: 3 Russian, 2 Western.

USSR

UDC 532.516:538.4

STABILITY OF CONVECTIVE FLOW OF A CONDUCTING FLUID IN A MAGNETIC FIELD

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 30-36  
manuscript received 1 Jun 77

BIRIKH, R. V., GERSHUNI, G. Z., ZHUKHOVITSKIY, YE. M., and RUDAKOV, R. N.

[Abstract] The steady plane-parallel convective flow of a conducting fluid through a flat vertical channel, with constant wall temperatures, is analyzed with necessary approximations by the Galerkin perturbation method and the Runge-Kutta method of stepwise orthogonalization. The differential equation for the amplitude of flow and temperature perturbations, first in a transverse and then in a longitudinal magnetic field, is solved and, on this basis, the stability limits are calculated in terms of the Grashof number as well as the Hartmann number. Plane perturbations are found to be most dangerous to stability in a longitudinal field, but no definite conclusion has been arrived at concerning the effect of spatial perturbations in a transverse field. Figures 6; references 5: 4 Russian, 1 Western.

CONVECTIVE STABILITY OF A VERTICAL LAYER OF MAGNETIZABLE FLUID IN A  
UNIFORM MAGNETIC FIELD

Riga MAGNITNAYA GIDRODINAMIKA in Russian, No 1, Jan-Mar 78 pp 27-29  
manuscript received 1 Jun 77

BASHTOVOY, V. G. and PAVLINOV, M. I.

[Abstract] An infinitely large plane vertical layer of magnetizable fluid is considered, this layer being heated from below and bounded on both lateral surfaces by ferromagnetic half-spaces. The fluid and the ferromagnetic material on both sides have the same pyromagnetic coefficient. The possibility of overcoming a convective instability of such a fluid layer in a uniform magnetic field is demonstrated by a solution of the equilibrium equation. The result indicates that such a magnetic field raises the stability threshold to full stabilization of the fluid layer, with the instability range in terms of the Rayleigh number now having both a lower and an upper limit. References: 3 Russian.

USSR

UDC 621.375.8

## EMISSION OF FAR-ULTRAVIOLET RADIATION DUE TO TRANSITIONS IN MULTICHARGE NEON-LIKE IONS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 417-421  
manuscript received 12 May 77

VAYNSHTEYN, L. A., VINOGRADOV, A. V., SAFRONOVA, U. I. and SKOBELEV, I. YU., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The energy of excited terms in  $2p^53s$ ,  $2p^53p$ , and  $2p^53d$  configurations have been calculated, according to the perturbation theory on the basis of hydrogen, and the wavelength of  $3s \rightarrow 2p$  or  $3d \rightarrow 2p$  transitions at which population inversion is possible have been determined for neon-like ions with  $Z = 4-17$ . The theoretical values, obtained from the energy matrix put in the form of a power series with coefficients found exactly from Feynman diagrams and including a relativistic as well as an empirical correction, agree very closely with experimental values available for Al IV - Fe XVII ions, within a 2% accuracy. The authors thank V. A. Boyko and Ye. A. Yukov for discussion. Figures 1; tables 2; references 17: 11 Russian, 6 Western.

USSR

UDC 535.373.3

## FLUORESCENCE OF MOLECULAR IODINE WITHIN THE 340 nm BAND OF WAVELENGTHS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 388-393  
manuscript received 18 Feb 77

STOYLOV, YU. YU., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The fluorescence of molecular iodine was analyzed, in the continuous mode, after excitation with xenon light passed through a monochromator. Iodine vapor was placed in a quartz crucible, with technically pure  $SF_6$ , He, Kr, Xe, or  $N_2$  as buffer gases. The fluorescence intensity was found to depend on the buffer gas and on its pressure. An increase in intensity within the 340 nm band, under higher pressure, is accompanied by an equivalent decrease in intensity within the 250-330 nm band, which indicates a collision transition of iodine molecules from the  $^1\Sigma_u^+$  state to the  $^3\Pi_{2g}$  state. The rate of this transition depends on the mass of buffer molecules as well as on the amount of vibration energy stored in iodine molecules. Little variation occurs up to 425°C.

These results agree with theory. The authors thank V. S. Zuyev, L. D. Mikheyev, and A. P. Shirokikh for discussing the results of this study. Figures 4; references 15: 4 Russian, 11 Western.

USSR

UDC 541.6:543.42/541.14:0.1.044

# LOCALIZATION OF VIBRONIC EXCITATION ENERGY AND SELECTIVE LASER CHEMISTRY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 235, No 5, 11 Aug 77  
pp 1118-1121 manuscript received 28 Apr 77

SHIGORIN, D. N. and KONOPLEV, G. G., Physicochemical Institute imeni L. Ya. Karpov, Moscow

[Abstract] It appears feasible to use the localization of vibronic excitation for selective photodissociation or for photochemical reactions between polyatomic molecules. The mechanism involved here consists of two stages: first producing a selective vibronic state by a source of electron excitation, with the excitation energy localized predominantly in active oscillators of a molecule, then selectively breaking down such a molecule or producing an interaction with the ambient medium by irradiation with infrared quanta at resonance frequencies. The probability of both processes is evaluated here theoretically. The paper was presented by academician Ya. M. Kolotyrkin on 28 Apr 77. References 11: 9 Russian, 2 Western.

USSR

UDC 541.14+546.22.16

# DISSOCIATION OF SF<sub>6</sub>-MOLECULES IRRADIATED BY A CO<sub>2</sub> PULSE LASER IN THE PRESENCE OF HYDROGEN HALOGENIDES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 235, No 5, 11 Aug 77  
pp 1075-1078 manuscript received 3 May 77

ARKHANGEL'SKIY, YU. I., KLIMOV, V. D., KUZ'MENKO, V. A., NEDOSEYEV, S. L., and LEGASOV, V. A., Corresponding Member of the USSR Academy of Sciences, Institute of Atomic Energy imeni I. V. Kurchatov, Moscow

[Abstract] A study was made to determine the effect of HF, HCl, HBr, HI, and Kr additives on the rate of SF<sub>6</sub> dissociation due to radiation from a CO<sub>2</sub> pulse laser. According to available data, the activation

energy was assumed to decrease in the HF - HCl - HBr - HI order. An ionization CO<sub>2</sub>-laser (CO<sub>2</sub>:N<sub>2</sub>:He=1:1:3) under atmospheric pressure was used in the experiment. The radiation pulses had an energy content of 35±4 J each over an 80 ns width, with a risetime of approximately 30 ns and a falltime of 0.5 μs. The molecules of hydrogen halogenides were found to facilitate de-activation of vibrationally excited SF<sub>6</sub>-molecules from levels below the dissociation state, conceivable only in terms of the collision mechanism. This is explained by either the smallness of the steric factor making the bimolecular chemical reaction SF<sub>6</sub>+HX (X denoting a halogen) less probable, or by the existence of stage limiting the rate of vibrational excitation. The authors thank V. V. Bulan and V. A. Lekomtsev for helping with the experiments. Figures 3; references 14: 11 Russian, 3 Western.



USSR

UDC 621.039.51.131

ON THE ONE-GROUP APPROACH TO CALCULATION OF THE NEUTRON-PHYSICS CHARACTERISTICS OF FAST REACTORS

Minsk IZVESTIYA AKADEMII NAUK BSSR, SERIYA FIZIKO-ENERGETICHESKIKH NAUK  
in Russian No 4, 1977 pp 19-25 manuscript received 20 Apr 77

PETLITSKIY, V. A., Institute of Nuclear Power Engineering, Academy of Sciences BSSR

[Abstract] The author considers the feasibility of using a one-group method to determine the critical load and other characteristics that influence the technical-economic indices of a fast reactor if each of these characteristics has its own precalculated set of one-group constants, assuming a minor change in the energy spectra and importances of neutrons over a certain range of variation in geometric and structural parameters. The one-group microconstants that are necessary in this approximation are obtained by averaging the many-group microsections with consideration of the importances of neutrons with respect to the corresponding characteristics. This averaging is based on the generalized theory of perturbations. An algorithm is given together with results of calculation in the one-group approximation for fast reactors with homogeneous core. The author thanks V. P. Slizov for formulating the problem, and also A. I. Kukhayev and L. I. Sal'nikov for constructive criticism. References 9 Russian.

USSR

UDC 621.378.9:533.9.02

EFFECT OF COLLISIONS BETWEEN LASER PLASMA STREAMS IN CONICAL TARGETS ON THE PLASMA PARAMETERS DURING LATER EXPANSION STAGES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 337-343  
manuscript received 28 Feb 77

BYKOVSKIY, YU. A., KOZYREV, YU. P., KOZLOVSKIY, K. I., and TSYBIN, A. S.,  
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[Abstract] A plasma stream resulting from irradiation of a hollow conical target with a laser beam is analyzed on the basis of experimental data which have been obtained with a ruby laser and a lead target. The charge (ion) distribution as well as maximum and mean velocities of ion scatter were measured with a plane target first and then with conical ones having gradually smaller aperture angles. An analysis of the results indicates that, as a flat target is replaced by an obtuse conical

one, collisions between plasma clusters at the surface produce a cumulative plasma jet along the cone axis. The maximum velocity first increases with smaller cone angles, but only some of the plasma flows along the cone axis; the remainder is brought to stagnation and its kinetic energy converted to heat. Below a critical range of cone angles (in this case  $40-45^\circ$ ), however, no cumulative plasma jet is formed and the maximum velocity along the cone axis decreases fast so that the velocity profile approaches the original one on a flat target. Now the total charge increases, concentrating more along the cone axis, and the kinetic energy of expanding plasma is effectively converted to heat. Figures 3; references 9: 6 Russian, 3 Western.

USSR

UDC 621.039.6:621.373.826

#### A HYBRID REACTOR ON THE BASIS OF LASER-DRIVEN FUSION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 349-358  
manuscript received 25 May 77

FEOKTISTOV, L. P., AVRONIN, YE. N., VARGANOVA, L. F., GADZHIYEV, A. D.,  
LYKOV, V. A., NECHAY, V. Z., and SHIBARSHOV, L. I.

[Abstract] The physical characteristics of a hybrid power reactor on the basis of laser-driven fusion are examined here and various design criteria for such a reactor are established. The target can be a solid sphere of deuterium-tritium ice, a thin hollow shell of deuterium-tritium ice, a hollow spherical glass or metallic shell containing either deuterium-tritium gas under high pressure or deuterium-tritium ice. The blanket can consist of a hollow spherical shell containing fuel (uranium) and coolant, or of a strong inner shell and an outer shell on both sides of the power zone. Both target and blanket fit inside a chamber. Thermo-nuclear neutrons produced in the target enter the blanket and cause here various reactions, the number of these reactions being determined from the neutron distribution spectrum by the Monte Carlo method. The closed power cycle of a typical 2500 MW reactor involves a laser delivering 1 MW (efficiency 1%) to the target, the target delivering 25 MW (gain 25) to the blanket, the blanket delivering 2500 MW (gain 100) to a turbine. The turbine delivers 900 MW to an electric generator, loses 1500 MW in heat, and supplies 100 MW to a storage device which transfer this power to the laser. Figures 10; references 23: 8 Russian, 15 Western.

INVESTIGATION OF THE PARAMETERS OF A  $\text{CO}_2+\text{N}_2+\text{He}^3$  GAS PLASMA FORMED IN THE CORE OF A STATIONARY REACTOR

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 1, Jan 78  
pp 39-41 manuscript received 20 Nov 76

BATYRBEKOV, G. A., MARDENOV, M. P., KUNAKOV, S. K., KLYUKIN, A. A.,  
KOMAROV, O. V., PETROV, N. N., TAKIBAYEV, ZH. S. and KHARITONOVA, K. S.,  
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[Abstract] In connection with the problem of developing an electron-beam-controlled  $\text{CO}_2$  laser for cw operation in the radiation field of a nuclear reactor, the authors use the probe method for in-pile plasma diagnosis of a  $\text{CO}_2+\text{N}_2+\text{He}^3$  gas mixture produced by the products of the  $\text{He}^3(\text{n},\text{p})\text{H}^3$  reaction and study the parameters of this plasma (electron density and temperature) as dependent on the thermal neutron flux and the pressure of the investigated mixture. The experiments were done in the central channel of the core of the VVR-K reactor at the Institute of Nuclear Physics of the Kazakh Academy of Sciences. It is found that as the thermal neutron flux increases from  $10^{13}$  to  $10^{14}$   $\text{n}/\text{cm}^2\cdot\text{s}$  and the pressure of the gas mixture rises from 0.5 to 10 atmospheres the electron density increases from  $10^{11}$  to  $2.1\cdot 10^{12}$   $\text{cm}^{-3}$ . This is attributed to an increase in the reaction rate and accordingly in the ionization rate as well as an increase in the partial pressure of  $\text{He}^3$ . The electron temperature increases somewhat with increasing thermal neutron flux and pressure. The temperature rise associated with neutron flux can be explained by the increased contribution of energy to the electron cloud with increasing ionization rate, while the pressure effect is due to an increase in ionization density that overbalances the electron temperature drop due to collisions with atoms. Another explanation for the rise in electron temperature could be an increase in electron density with increasing gas pressure since recombination losses of ions and electrons decrease with a rise in electron temperature. The authors thank K. N. Ul'yanov and K. P. Novikova for consultation on the method of processing and analyzing the probe characteristics of the dense plasma, and also A. A. Babushkin, Yu. D. Kuznetsov, V. P. Kiselev, A. S. Zaslavets and V. T. Tret'yakov for assistance with the work. Figures 2, references 4 Russian.

USSR

FEASIBILITY OF DOUBLING THE ENERGY IN LINEAR ACCELERATORS

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR, FIZIKA in Russian Vol 13,  
No 1, 1978 pp 60-64 manuscript received 17 Nov 76

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[Abstract] Various methods of increasing the energy level in the Stanford Linear Accelerator Center, namely by the use of superconducting accelerator segments or by recirculation of the electron beam, have so far failed because of technical and economical difficulties. Another approach to the problem has led to an energy doubling technique, on the basis of raising the peak rf pulse power without changing the average input power. This is achieved with high-Q coupled resonator cavities and by phase inversion at the appropriate instant of time. The validity of this method derives from the equation of power balance, power being proportional to the electric field intensity squared, and from the field characteristics of a wave traveling through an accelerator waveguide. The feasibility of this method has been demonstrated in actual tests with the appropriate accelerator and pulse parameters. References: 6 Western.

USSR

UDC 535.34.08:551.510.534:541.14

## LASER PHOTOCHEMISTRY OF OZONE AND REMOTE SPECTROSCOPY

Toms'k IZVESTIYA VUZov: FIZIKA in Russian No 11(186), Nov 77 pp 154-176

KOPYLOVA, I. M. and SUKHORUKOV, A. P., Moscow State University imeni M. V. Lomonosov

[Abstract] A theoretical examination is made of the change in ozone concentration under the influence of laser emission. The characteristics of atmospheric ozone are briefly outlined, and it is shown that the action of laser emission on the entire thickness of the atmosphere can be determined by considering only the stratospheric layer and disregarding the minor contribution to light absorption by the ozone below 15 km and above 40 km. This idealized model enables analysis of the main patterns of laser photochemistry of ozone and numerical calculation of processes for the major stratum of the atmosphere. The basic theory for the analysis of photochemical processes takes account of reactions between ozone, atomic and molecular oxygen and neutral air molecules that acquire surplus kinetic energy in collisions. Basic equations are derived within this "dry" theory of photochemical dissociation of ozone in the presence of laser emission. The induced change of ozone concentration in a given laser field is considered for an isolated pulse, for a periodic pulse train, and also with regard to the influence of excited atomic oxygen particles. Dissociation of ozone by a laser beam with weak absorption is discussed, and the case of beam propagation in the presence of ozone with strong absorption is examined for homogeneous and inhomogeneous media, vertical probing of the atmosphere with consideration of diffraction of the laser beam, opposed motion of the laser beam and layers of the medium, side winds and scanning. Some refinements of the "dry" theory of photochemical dissociation are discussed in which consideration is taken of photochemical reactions with various minor components of the atmosphere: the "wet" theory that accounts for reactions with water vapor, and Smirnov's theory that introduces corrections for the influence of the nitrogen cycle of ozone dissociation. Figures 10, references 35: 12 Russian, 23 Western.

## EFFECT OF NONPLANARITY OF A LASER EMISSION WAVE ON THE ACCURACY OF MEASUREMENTS IN A TWO-BEAM INTERFEROMETER

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 44, No 4, Apr 78 pp 799-801 manuscript received 14 Dec 76

SHUR, V. L. and ETSIN, I. SH.

[Abstract] The effect of divergence of a laser beam on the accuracy of path-difference measurements in a two-beam reflecting interferometer is evaluated in the case of an interference band cut to finite width by passing through a slit. The phase shift in the objective of a "reverse telescope," or without collimation, is calculated as a function of the slit width, with correction for the phase shift at the axis. The results are compared with those for an "infinitely" wide band and for a circular iris. The authors thank E. Ye. Fradkin and V. M. Khavinson for discussion. Figures 2; references 6: 3 Russian, 3 Western.

USSR

UDC 778.38:535.36

REFLECTION HOLOGRAMS IN  $\text{LiNbO}_3\text{:Fe}$  CRYSTALS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 440-442  
manuscript received 20 Jul 77

MIKHAELIAN, A. L., GULANYAN, E. KH., DMITRIYEVA, YE. I., and DOROSH, I. R.

[Abstract] The feasibility of reflection holography in  $\text{LiNbO}_3\text{:Fe}$  crystals has been established in recording and reproduction experiments. The iron concentration in these crystals was 0.03 wt.%, the angle between signal beam and reference beam was approximately  $170^\circ$ . The maximum diffractive efficiency at the  $0.63 \mu\text{m}$  wavelength in a 5 mm thick crystal required an exposure to  $180 \text{ J/cm}^2$  of radiation, but a 25% efficiency could already be attained with  $12 \text{ J/cm}^2$ . Transmission holograms were also recorded, for comparison, with longer spatial periods. In this case the maximum efficiency was approximately the same, but the sensitivity was slightly higher because of less absorption. Thus  $\text{LiNbO}_3$  crystals appear to be suitable for high-capacity information storage. Figures 5; references 4: 1 Russian, 3 Western.

USSR

UDC 621.378

REPRODUCTION OF WAVEFRONTS BY SCATTERING OF LIGHT ON ACOUSTIC WAVES AND BY DYNAMIC HOLOGRAPHY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 436-437  
manuscript received 14 Jul 77

GERASIMOV, V. B. and ORLOV, V. K.

[Abstract] Reproduction of the wavefront of incident light during stimulated scattering is shown to be a new phenomenon associated with nonlinear and parametric optics, rather than due to a spatially nonuniform intensity of laser pumping. An analysis of stimulated scattering by acoustic waves reveals an analogy to dynamic holography. It also reveals certain advantages of an "acoustic" mirror over a Brillouin mirror, inasmuch as the reflection coefficient does not depend on the intensity of the incident light so that, in the absence of a reflectivity threshold, the length of an "acoustic" mirror can be made arbitrarily small. A combination of both mirrors, the "acoustic" one operating at the anti-Stokes frequency, makes feasible a resonator with stable oscillation at two frequencies. The accuracy of reproduction depends on the angular spectrum of the excited acoustic wave as well as on the degree of collinearity between the preferred directions of light wave and acoustic wave propagation, also on

how closely the scattering process has been approximated. References:  
9 Russian.

USSR

UDC 621.378.9:535.6

COHERENCE CHARACTERISTICS OF A COPPER VAPOR LASER AND DYNAMIC HOLOGRAMS  
ON VO<sub>2</sub>-FILMS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 425-428  
manuscript received 2 Jul 77

ZEMSKOV, K. I., KAZARYAN, M. A., MOKEROV, V. G., PETRASH, G. G., and  
PETROVA, A. G., Institute of Physics imeni P. N. Lebedev, USSR Academy  
of Sciences, Moscow

[Abstract] Dynamic holography in 2  $\mu$ m thin single-crystal and polycrystalline VO<sub>2</sub>-films on substrates of sapphire and fused quartz, with copper vapor as the laser source operating at the frequency of 12.5 kHz and with an optical system consisting of three mirrors around a beam splitter, was used for measuring the spatial as well as the time coherence of such a laser. As the optical path difference between the two interfering rays increased from 0 to 20 cm, the time coherence changed from total to zero diffraction. An indication of spatial coherence was the presence of a diffracted ray even with the overlap of the two interfering ones reduced to a minimum. The diffractive efficiency as a function of the mean laser power was found to reach the maximum at approximately 100 mW. Optical modulation of the phase transition in VO<sub>2</sub>-films on sapphire was also achieved, at frequencies within the 5-18 kHz range, without a reduction of efficiency after 10<sup>8</sup> recording-erasing cycles. Figures 3; references 8: 7 Russian, 1 Western.

USSR

UDC 621.375.826

MUTUAL QUENCHING OF AXIAL MODES IN TWO-MODE LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 344-348  
manuscript received 4 Apr 77

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of Sciences, Moscow

[Abstract] Optical oscillations between two stable levels, and an attendant hysteresis, can occur in solid-state lasers with two axial



modes in the same resonator cavity, provided the relaxation time with respect to population of energy levels is much shorter than the inter-mode beat period. The parameters of such oscillations are calculated here on the basis of theoretical relations characterizing the electric field inside a resonator. As a result, the feasibility is demonstrated of producing two mutually quenching modes. This effect can be utilized in optical memory or logic devices where high switching speed with a low energy per cycle is desirable. Figures 1; references 23: 10 Russian, 13 Western.

USSR

UDC 778.39

#### GEOMETRICAL FACTORS INVOLVED IN DYNAMIC HOLOGRAPHIC CONVERSION OF LIGHT BEAMS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 405-411  
manuscript received 15 Feb 77

VINETSKIY, V. L. and KUKHTAREV, N. V., Institute of Physics, Academy of Sciences of the Ukrainian SSR, Kiev

[Abstract] The boundary conditions are very important in dynamic hologram recording, especially when the parameters of a light beam change during passage through a medium with a variable refractive index. This is illustrated here in the conversion of two plane light waves with a sinusoidally varying electric field intensity by an isotropic medium such as an electro-optic  $\text{LiNbO}_3$  crystal. The gain is shown to increase upon change from transmission-type geometry to reflection-type geometry, regardless of the spatial period of the grating. This period can be effectively adjusted by means of an external electric field. The authors thank S. G. Odulov, B. D. Pavlik, M. S. Soskin, and A. I. Khizhnyak for very useful discussion of these results. Figures 2; references 9: 4 Russian, 5 Western.

USSR

UDC 621.378.33

AN APPARATUS FOR EXAMINING THE EMISSION IN VAPORS OF PURE METALS IN A TRANSVERSE DISCHARGE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 442-444  
manuscript received 2 Aug 77

BOGUS, A. M., DZHIKIYA, V. L., and CHERNOV, A. A.

[Abstract] Transverse pulse discharge was tested on vapors of pure metals in an apparatus consisting of 19 molybdenum anode segments and a slit molybdenum cathode, the latter serving also as a container for the vaporizing metals and heated from a separate current source. Laser tests were performed with Sr II ions and helium as the buffer gas under various pressures. Optimum emission at the 430.5 nm wavelength was attained under 60 mm Hg helium pressure and at 530°C, this temperature corresponding to  $8 \cdot 10^{-3}$  mm Hg of strontium vapor, with a discharge current of 1.1 kA at a voltage of 3.4 kV across the capacitors. No emission at the 416.5 nm line of Sr II occurred under any discharge conditions. It appears feasible to further increase the laser intensity with heavier discharge currents. Figures 3; references 8: 4 Russian, 4 Western.

USSR

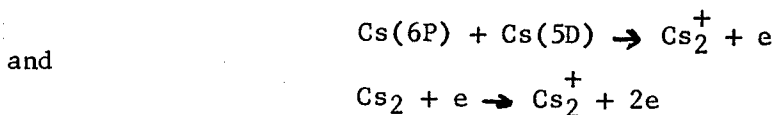
UDC 537.527

EFFECT OF THE NITROGEN PRESSURE ON THE RATE OF  $\text{Cs}_2^+$ -ION GENERATION IN AN N-Cs DISCHARGE PLASMA

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 717-721 manuscript received 11 Jul 77

BORODIN, N. A. and KORCHEVOY, YU. P., Institute of Electrodynamics,  
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[Abstract] The generation of molecular  $\text{Cs}_2^+$ -ions in an N-Cs discharge plasma under various nitrogen pressures was studied and the characteristics of such a plasma were determined. On the basis of experimental data, it is possible to analyze the relative contributions of processes



to the rate at which these ions are generated. The observed decrease in the  $\text{Cs}_2^+$ -ion generation rate with increasing nitrogen pressure is attributed to a quenching of the population of 6P and 5D states in cesium atoms which participate in the more efficient process of associative ionization. Figures 4; references 5: 4 Russian, 1 Western.

USSR

UDC 621.373.826:53

# HEATING OF MOLECULAR GASES IN A SEMI-SELF-MAINTAINED DISCHARGE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 712-716 manuscript received 27 Jul 77

BURTSEV, V. A., KONDAKOV, A. A., POPONIN, V. P., SMIRNOV, V. G., and SHANSKIY, V. F., Scientific Research Institute of Electrophysical Apparatus imeni D. V. Yefremov, Leningrad

[Abstract] The basic laws which govern the heating of molecular gases in a semi-self-maintained electron-beam controlled discharge are analyzed by a theoretical interpretation of experimental data. Discharges in  $\text{CO}_2:\text{N}_2:\text{He}=1:2:3$  and  $1:1:8$  mixtures between a steel mesh and a flat copper anode 5 cm apart were produced by a 180 keV electron beam with a  $0.2 \text{ A/cm}^2$  current density. With a 50 kV capacity available, it was possible to generate rectangular voltage pulses of either polarity and 8  $\mu\text{s}$  duration. Interferograms of the discharge were recorded, and the velocity of the shock wave as well as the temperature in the gas were measured at various levels of the pumping power from 70 to  $130 \text{ kW/cm}^2$ . The results are evaluated mathematically, assuming a negligible diffusion and a constant  $E/N$  ( $\text{V}\cdot\text{cm}^2$ ) ratio during a pumping pulse, assuming a gas concentration which remains uniformly distributed over the discharge volume outside the shock zone and varies exponentially with time during heating and expansion, and assuming the heating of the gas due to collisions with electrons to be negligible to its heating due to relaxation of the vibration energy. Figures 3; references 15: 8 Russian, 7 Western.

## EFFECTIVENESS OF DIRECT IONIZATION BY ELECTRONS OF DIATOMIC MOLECULES OF ALKALI METALS IN A DISCHARGE PLASMA

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 1, Jan 78  
pp 80-85 manuscript received 25 Aug 75, after final revision 17 Jan 77

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[Abstract] An estimate is made of the contribution made by electrons of dimers of  $K_2$ ,  $Rb_2$  and  $Cs_2$  to the rate of generation of molecular ions of direct ionization in an alkaline discharge plasma. The conditions are established under which the principal mechanism of formation of ions is direct ionization of dimers by electrons. Because of a lack of reliable data on dimer concentration in saturated vapors of alkali metals, the quantitative characteristic of this process is given in the form of the product of two unknowns: the cross section and concentration of the dimers at a predetermined temperature of the saturated vapor. Figures 3, references 16: 12 Russian, 4 Western.

## ANOMALIES OF THE IONIZATION MECHANISM IN A LOW-VOLTAGE ARC IN AN INERT GAS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 688-699 manuscript received 23 May 77

BAKSHT, F. G. and IVANOV, V. G., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] An explanation is sought for the anomalous ionization mechanism in cold plasma of inert gases, in a low-voltage arc with the pd-product (pressure  $\times$  electrode spacing) within the 1-10 torr $\cdot$ cm range. The characteristic lengths and the ionization rates are calculated for atomic ions as well as for molecular ions, taking into account not only generation and recombination but also diffusion. The results of calculations for xenon, neon, and argon indicate that ionization here varies stepwise depending on the degree of ionization. Atomic ions are generated at a rate which at low degrees of ionization depends on the emission and the distribution of fast electrons, but at intermediate degrees of ionization ( $\beta_e = 10^{-3}$ - $10^{-2}$ ) depends only on the electron temperature. Molecular ions recombine fast and, therefore, do not contribute much to the plasma

concentration. Atomic ions also recombine to reach an ionization equilibrium at sufficiently high degrees of ionization and values of the  $pd$ -product, while at not so high degrees of ionization their generation may be balanced not by their recombination but conversion to molecular ions. The authors thank A. A. Bogdanov, A. M. Martsinovskiy, and V. G. Yur'yev for discussion of this study and valuable comments. Figures 6; references 30: 9 Russian, 1 German, 20 Western.

USSR

UDC 533.9.621.039.667.6

MEASUREMENT OF THE INTEGRAL ELECTRON CONCENTRATION IN A PLASMOCHEMICAL DEVICE WITH A THREE-MIRROR SUBMILLIMETER INTERFEROMETER

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16, No 2, Mar-Apr 78 pp 413-415 manuscript received 10 Jun 77

ATAMANOV, V. M., LEVADNYY, G. B., NASEDKIN, YU. F., NIKIFOROV, V. A., PETROV, G. D., PETRYAKOV, A. I., and SAMARSKIY, P. A., All-Union Scientific Research Institute of Physicotechnical and Radiotechnical Measurements

[Abstract] The rate of some plasmochemical reactions depends strongly on the integral concentration of electrons within the plasma volume. This concentration was measured with a three-mirror submillimeter interferometer. The light beam from an HCN-laser ( $\lambda = 337 \mu\text{m}$ ) was first deflected by a plane mirror and then split by another plane mirror into two: one reflected directly to a pyroreceiver and one transmitted to the plasma chamber through a condenser lens and then a quartz window. Upon crossing the electron beam at right angles inside the plasma chamber and then leaving the latter through another quartz window on the other side, this second beam passed through another condenser lens and struck a spherical mirror, to be reflected back along the same path. The interference pattern was scanned by shifting the spherical mirror by means of a motor-driven micrometer screw. Oscillograms of the interference pattern were recorded and the integral concentration of electrons in the helium plasma was measured as a function of the electron beam energy at several levels of the gas pressure. On the basis of these data, the degree of ionization could be estimated at approximately  $10^{-2}$  and deemed sufficiently near optimum for a dissociation process to occur. Figures 4; references: 5 Russian.

USSR

UDC 533.951.2

EXCITATION OF OSCILLATIONS BY HOT ELECTRONS IN A CRYOGENIC HELIUM  
PLASMA

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16, No 2, Mar-Apr  
78 pp 258-264 manuscript received 10 May 77

SAMOVAROV, V. N., Physico-Chemical Institute of Low Temperatures, Academy  
of Sciences of the Ukrainian SSR

[Abstract] An analysis of a decaying cryogenic helium plasma, without  
impurities and with negligible diffusion, reveals that collective oscil-  
lations in it due to heating of the gas by hot electrons are due to an  
oscillatory decrease in the density of metastable atoms during the plasma  
deionization. The feasibility of exciting and amplifying a sound wave by  
this mechanism is theoretically established. The author thanks I. Ya.  
Fugol' and A. M. Ratner for assistance. References 18: 10 Russian,  
8 Western.

USSR

EXPERIMENTAL STUDY OF THE MECHANISM OF TURBULENT HEATING OF A PLASMA  
WITH TRANSVERSE CURRENT

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 73  
No 2(8), Aug 77 pp 506-515 manuscript received 28 Jan 77

VIRKO, V. F. and KIRICHENKO, G. S., Institute of Nuclear Research,  
Academy of Sciences UkrSSR

[Abstract] The plasma of an ion beam traveling across a magnetic field  
with neutralization by electrons is studied with regard to the nature  
and structure of the stimulated low-frequency waves, the dynamics of  
establishment of the nonlinear spectrum, correlation characteristics of  
oscillations, and heating of ions and electrons in the mode of in-  
stability saturation. It is found that turbulence arises as a result  
of stimulation of ionic-acoustic oscillations propagating across the  
magnetic field. The oscillations are unstable over a wide range of  
wavelengths, the lower limit being the Larmor radius of the electrons.  
Effective nonlinear transformation of the noise spectrum takes place  
in the direction of a reduction in frequencies (wave numbers). An  
experimental study is done on the structure of the wave process in  
k-space, and it is demonstrated that the stimulated phases are three-  
dimensional and that correlation of their phases is disrupted. In the

region of large wave numbers the steady-state nonlinear spectrum is characterized by an exponential drop in amplitude of noises with increasing  $k$ . The final state of the plasma is characterized by an ion temperature that is lower than or of the order of the electron temperature, which is due to rapid heating of ions as a result of capture by ionic-acoustic waves. Figures 9, references 14: 11 Russian, 3 Western.

USSR

UDC 533.932

#### DETERMINING THE ELECTRICAL CONDUCTIVITY OF AN AEROSOL PLASMA

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16, No 2, Mar-Apr 78 pp 225-230 manuscript received 11 Jul 77

GORBATOV, A. V. and SAMUYLOV, YE. V., Power Engineering Institute imeni G. M. Krzhizhanovskiy, Moscow

[Abstract] The effect of an electric field on the electrophysical properties of an aerosol plasma, consisting of aerosol particles which emit thermal electrons, is analyzed on the basis of the elementary theory with a strong electric field and also on the basis of the kinetic theory with a weak electric field. For a highly dispersed plasma with the mean electron energy much higher than the kinetic energy of thermal motion of molecules, the electrical conductivity is calculated and found to depend on the cross sections of electron scatter and absorption by aerosol particles as well as on the ratio of electron heating time to electron life time. References 15: 12 Russian, 3 Western.

USSR

UDC 537.533.3

#### PARAMETERS OF A PLASMA IN A HOLLOW COLLECTOR

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78 pp 681-687 manuscript received 6 Jul 77

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[Abstract] A hollow collector is used in optoelectronic devices for deceleration of electrons and recovery of their energy. Its performance is most efficient at the minimum collector potential, where ions produced

by collisions of electrons with the residual gas accumulate in the potential well and compensate the negative space charge. The parameters of such a plasma were measured in a Faraday cylinder serving as a collector, where the energy of a 100 mA strong electron beam from an electron gun was decelerated to 200 eV under a gas (nitrogen) pressure ranging from  $10^{-5}$  to  $10^{-4}$  torr. As a result, the axial distributions of ion and electron current densities as well as both the axial and the radial distributions of potential in the collector were determined at various gas pressures. An analysis of the experimental data, in close agreement with the solution to the Poisson equation for a spherical model, indicates that the potential dip in the collector corresponds to a quasi-neutral gas stream with an approximately 2% decompensation of the space charges. The plasma potential in the collector is almost uniformly distributed in space, with a minimum near the iris. A potential barrier near the collector entrance separates regions of small and large potential gradients, its location being almost independent of the electron beam current and of the gas pressure. The ion temperature in this experiment was anomalously high, ranging from 13 to 25 eV, and the equations of ion balance in the collector should, with these data, yield the dependence of the potential dip on the pressure of residual gas. The author thanks A. V. Zharinov for discussion of this study and helpful comments. Figures 7; references 10: 9 Russian, 1 Western.

USSR

UDC 533.932

#### EFFECT OF A SHORT CIRCUIT IN A CONSTRAINED PLASMA

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 707-711 manuscript received 21 Jul 77

ZHILINSKIY, A. P., KUTEYEV, B. V., and SMIRNOV, A. S., Leningrad Polytechnic Institute imeni M. I. Kalinin

[Abstract] An experimental study was made to determine the causes of a weak short circuit in devices with a plane anode. The measurements were made in cylindrical containers, 3.8-4.2 cm in diameter and 60-75 cm long, with a decaying helium plasma under a pressure of the neutral gas ranging from 0.05 to 0.12 torr. The cathode was cylindrical and the anode was either cylindrical or a flat disk, with the cylindrical plasma container between both electrodes and its lateral wall serving as a third electrode. Most of the intensity drop of the axially oriented 3 kOe strong magnetic field occurred across the cathode. With a short circuit between anode and cathode or between either of them and the third electrode, the difference between cathode current and anode current was found to increase with decreasing magnetic field intensity, probably due to an anomalous



field dependence of the reciprocal of the short-circuit lifetime. Most effective was a short circuit between the anode and the third electrode. The shape of the electrode involved in a short circuit does not seem to be a factor affecting the nonambipolar loss of particles. The weakness of the short-circuit effect may be due to an appreciable departure of the initial concentration profile from a diffusional one. The authors thank V. Ye. Golant for unwavering interest in and support of this study, also S. N. Davydov and V. M. Voronov for help in preparing several experiments. Figures 3; references 7: 5 Russian, 2 Western.

USSR

UDC 537.521

#### BEHAVIOR OF THE NEUTRAL GAS IN A WEAKLY IONIZED PULSE-DISCHARGE PLASMA

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 722-726 manuscript received 29 Oct 76; after revision, 6 Sep 77

SKREBOV, V. N. and EYKHAL'D, A. I., Leningrad State University imeni  
A. A. Zhdanov

[Abstract] Local gas densities and temperatures in a partially ionized argon plasma were recorded with an interferometer as functions of time, after pulse discharges of 1-3  $\mu$ s duration and with an energy content of  $10^{-3}$ - $10^{-1}$  J had been produced in a cylindrical tube. The gas was weakly ionized with a 1-3 mA direct current, to maintain a symmetric discharge, but the latter was severely constricted to a radius much smaller than the tube radius of 10 mm. The results are interpreted according to a theory of gas dynamics under weak excitation and intermediate pressure, and on the basis of the solution to the fundamental field equations describing the variation of density, pressure, and heating rate. The neutral gas is assumed to be ideal, with a finite acoustic velocity but zero viscosity and zero thermal conductivity. This theory explains the observed trend of density fluctuations with increasing energy input: their amplitude first rising to a certain level and then dropping again; except at the tube walls, where it increases monotonically with higher input energy. Figures 1; references 7: 6 Russian, 1 Western.

USSR

UDC 621.371.24

PLASMA PROBING WITH CONSIDERATION OF HORIZONTAL GRADIENTS IN THE MEDIUM  
AND OF THE PROBE'S FINITE RADIATION PATTERN

Gor'kiy IZVESTIYA VUZOV, RADIOFIZIKA in Russian Vol 21, No 3, Mar 78  
pp 333-337 manuscript received 14 Mar 77

GOTSAKOVA, L. S. and YASHIN, YU. YA., Gor'kiy State University

[Abstract] In probing a plasma such as the ionosphere at frequencies below critical it becomes necessary to take into account the finite width of the probe's radiation pattern, especially in a medium with large horizontal gradients of the electron concentration. It is shown here, on a simple example of a spherically stratified medium simulating a segment of the ionosphere, that otherwise the return of the reflected signal to its source point may be interpreted ambivalently with respect to the incidence angle. This is due to the fact that, for certain relations between plasma parameters and wave frequency, the length of the optical path becomes a bifurcated function of the probing signal frequency. The number of branching points can further increase, as the curvature radius of the ionosphere boundary changes. The authors thank B. N. Gershman, L. M. Yerukhimov, Yu. A. Ignat'yev, and D. S. Kotik for discussing the results of this study. Figures 4; references 7: 4 Russian, 3 Western.

USSR

UDC 533.92:621.039.01

OPTIMUM PARAMETERS OF A FREELY EXPANDING DENSE PLASMA OF A MIXTURE OF  
DEUTERIUM AND TRITIUM

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 47, No 10, Oct 77  
pp 2220-2221 manuscript received 8 Jul 76

KOLESNIKOV, YE. K. and ROZOV, A. L., Leningrad State University imeni  
A. A. Zhdanov

[Abstract] Calculations are done to determine the optimum parameters of a freely expanding deuterium-tritium plasma that yields thermonuclear energy to equal or surpass the thermal energy of the plasma. The energy released as a result of fusion reactions in the dispersal process is calculated on the assumption that the temperature at time zero in the quiescent plasma ball is distributed parabolically with respect to the radius. In this special case, the Artsimovich formula gives an optimum initial radius of 0.23 cm with corresponding minimum energy input of  $9.7 \cdot 10^6$  J, and the Kozlov formula gives a minimum value of  $5.0 \cdot 10^6$  J at

an optimum initial radius of 0.18 cm. A positive energy yield becomes impossible in the former case for initial radii smaller than 0.22 cm, and in the latter case for radii smaller than 0.16 cm. It is noted that accounting for hydrodynamics leads to much lower values of the necessary energy input. Figure 1, references 6 Russian.

USSR

UDC 538.574.5:533.9.01

# ABSORPTION OF THE ENERGY OF ELECTROMAGNETIC WAVES IN A RANDOMLY NON-HOMOGENEOUS COLLISIONLESS PLASMA AT PLASMA RESONANCE FREQUENCIES

Gor'kiy IZVESTIYA VUZOV, RADIOFIZIKA in Russian Vol 21, No 3, Mar 78  
pp 316-325 manuscript received 3 Aug 76

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[Abstract] The antihermitian part of the effective permittivity tensor is calculated for a magnetically active plasma, this part of the  $\epsilon_{ij}^{eff}(\omega, k)$ -tensor being formally related to the poles of the Green function  $G_{ik}^0(\omega, k)$  at points defined by the equation  $p^2 = k_{1,2}^2(\omega)$ . The resonance direction corresponds to angle  $\alpha = \alpha_p$  at which  $N(\alpha) = \epsilon \sin^2 \alpha + \gamma \cos^2 \alpha = 0$  and the refractive index for the extraordinary wave becomes infinitely large. Small-scale fluctuations of the electron concentration are considered in the cases of isotropic, weakly anisotropic, and strongly anisotropic inhomogeneities. The results render an adequate description of dissipative processes in a collisionless plasma which occur due to scattering. References 8: 7 Russian, 1 Western.

USSR

UDC 533.951

# PLASMA-BEAM INSTABILITIES IN A PERIODIC ELECTRIC FIELD

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 23, No 4, Apr 78  
pp 549-555 manuscript received 30 May 77; after revision, 22 Sep 77

TKACHENKO, V. I. and TKACHENKO, Vl. I., Khar'kov State University imeni A. M. Gor'kiy

[Abstract] The instability due to interaction of a plasma and a low-density electron beam in a modulating external electric field with a periodic potential profile is analyzed, this interaction being assumed

to take place inside an ideally conducting waveguide without or with a uniform magnetic field of finite intensity. From the dispersion equation describing the interaction in the three-wave approximation, the instability increments are calculated for various relevant wave numbers and corresponding ranges of the field phase velocity relative to the beam velocity. Various instability modes are found to occur depending on this phase velocity and, as the latter comes close to the beam velocity, the instability increments here differ from those of beam instability by an amount proportional to the modulation index of the beam electrons (the modulation of plasma electrons remaining insignificant). The authors thank A. N. Kondratenko and V. M. Kuklin for discussing the results and for interest in this study. Tables 4; references: 5 Russian.

USSR

UDC 593.951

#### STABILITY OF A PLASMA WITH A NEGATIVE COLLISIONAL CONDUCTANCE

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 23, No 4, Apr 78  
pp 597-600 manuscript received 26 Sep 77

BRODSKIY, V. B.

[Abstract] A plasma with negative conductance has been found to be an unbalanced inversion medium amplifying electromagnetic waves. The stability of such a plasma is analyzed here, considering not only the electric field of the space charge but also the diffusion of electrons. Diffusion of electrons counteracts the compression of space charge and can establish a nonlinear limit for instability, if the conductance does not depend on the electric field intensity. The equilibrium condition is found by equating to zero the sum of conduction current and diffusion current, with the ions assumed to be stationary and the frequency of elastic electron-atom or electron-molecule collisions assumed to be much higher than the plasma frequency. Also the power of an external supply necessary for maintaining a plasma in the negative-conductance state is closely estimated, namely approximately  $100 \text{ erg}/(\text{cm}^3 \cdot \text{s})$  for xenon under typical conditions. The author thanks Ya. B. Faynberg and S. S. Moiseyev for the interest shown in this study. Figures 1; references 4: 2 Russian, 2 Western.

USSR

UDC 537.533

MEASURING THE DEGREE OF IONIC COMPENSATION OF THE SPACE CHARGE DUE TO AN ELECTRON BEAM

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 727-731 manuscript received 7 Jan 77; after revision, 14 Jun 77

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[Abstract] An attempt was made to measure the degree of compensation, by an ionic space charge, of the electronic space charge due to an electron beam in imperfect vacuum. A low-current probing electron beam striking the main beam at right angles was used for this purpose. This method is based on electron ballistics and beam deflection by electrostatic fields. The deflection of the probing beam by the space-charge field of the main beam was measured at various accelerating voltages and at various gas pressures, a small deflection indicating a high degree of compensation. Figures 4; references 7: 5 Russian, 2 Western.

USSR

UDC 533.9.07

PULSATING PRESSURE IN HIGH-CURRENT DISCHARGES WITH A VAPORIZING WALL

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 732-735 manuscript received 12 May 77

GOLUBEV, YE. M. and OGURTSOVA, N. N.

[Abstract] The pressure in the plasma of a high-current discharge with a vaporizing wall was measured with a piezoelectric transducer and by the crusher method. A discharge of 180 kA was produced inside a fiber tube 45 mm in diameter and 200 mm long as well as in a quartz lamp with a gaseous shield and the same characteristic dimensions. Both methods of measurement revealed a pressure pulse behind a current pulse in such a discharge, due to inertial gas leakage through the tube ends and due to hydromagnetic instability. The pressure readings by both methods agreed, within a  $\pm 10\%$  measurement accuracy, the crusher indicating a pressure at the center of the current channel equal to the sum of measured gas pressure at the tube wall and calculated magnetic pressure at the discharge axis. Figures 4; references: 8 Russian.

## SHAPING OF A HIGH-CURRENT DISCHARGE AND ITS DYNAMICS IN A CONTROLLED VACUUM COMMUTATOR

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DASHUK, P. N., KICHAYEVA, G. S., SERGEYENKOVA, YE. A., and SHKUROPAT, P. I., Leningrad Polytechnic Institute imeni M. I. Kalinin

[Abstract] The performance of a cylindrical commutating vacuum discharger with two main electrodes and a triggering device in a container with insulating walls of acrylic plastic was measured in an experiment with a high-speed photo-recorder. Currents of up to 10 kA from a capacitor bank rated at 10 kV, were switched and the currents were recorded for the first few half-periods. The asymmetric glow spikes, corresponding to zero-crossovers of the underdamped transient current, could be attributed to recurring flashovers in the gas emitted from the container wall as a result of desorption and evaporation. The value of the discharger circuit parameters (dynamic resistance  $R_d = (\frac{1}{I}) \frac{di}{dt} = 0$  and inductance  $L_d = V_i = 0 \cdot \frac{di}{dt}$ ) and the rate of change of current  $di/dt$  at the current zero-crossover points were calculated from the photorecorder current curve and its derivative. Figures 3; tables 1; references 8: 7 Russian, 1 Western.

## A METHOD OF MEASURING THE TEMPERATURE OF A LASER PLASMA

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78  
pp 742-745 manuscript received 10 May 77; after revision, 4 Jul 77

MOTYLEV, S. L. and PASHININ, P. P., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A method is proposed for measuring the temperature of a laser plasma near the surface as a function of time. The time resolution of this method depends on the stray inductances in the signal recording circuit and can reach  $10^{-10}$  s. This method is based on the appearance of a space-charge double layer at the plasma boundary, the laser beam being focused on a metallic target inside a vacuum chamber. When the pressure of the residual gas is very low, of the order of  $10^{-6}$  torr, then the Debye radius is much larger than the characteristic dimensions of the chamber and the wall of the latter forms with the target a capacitor across a load resistor connecting the target to the probe and picking up the signal. At a sufficiently high pressure of the residual gas the

Debye radius becomes much smaller than the characteristic chamber dimensions, although it can be increased by moving the probe wire farther away from the focal spot, with the signal now determined by the emf of the double layer. The operation of the instrument is illustrated in the case where the emission current flows around the longest possible closed path through the plasma of the residual gas, the probe, the load resistor, the target, and the laser plasma. Both low-frequency and high-frequency measurements are shown. Figures 3; references 6: 4 Russian, 2 Western.

USSR

UDC 533.9.07

CHANGE OF THE DISCHARGE MODE AND EROSION OF THE ANODE IN AN END-WINDOW PLASMA ACCELERATOR OPERATING UNDER SUPERCRITICAL CONDITIONS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 48, No 4, Apr 78 pp 746-753 manuscript received 3 May 76; after revision, 24 Aug 77

VAYNBERG, L. I., LYUBIMOV, G. A., and SMOLIN, G. G., Moscow Aviation Institute imeni S. Ordzhonikidze

[Abstract] The performance of an end-window plasma accelerator with lithium as the active medium was measured at constant flowrates with the current increasing beyond its critical level (540 A) at which the anode potential as well as the "floating" probe potential relative to the anode also begin to increase. The charge density at the probe location was calculated from the ion saturation current and the electron temperature was calculated from the voltage-current characteristic of the probe. The results confirm that the ratio of critical current squared to rate of lithium consumption remains constant. The anode fall of potential increases exponentially from low negative values to high positive values, the change of sign corresponding to the second critical current level depending on lithium flow. At this point there appear oscillations at the probe and in the accelerator supply circuit, their fundamental frequency approximately equal to the ratio of ion-acoustic velocity to anode radius, so that the performance becomes unstable. Meanwhile the tungsten anode, whose temperature has also been increasing exponentially, erodes by evaporation. When the anode potential drop exceeds the ionization potential of tungsten, while the mean free path of particles decreases to the characteristic dimension of the anode fall region, impact ionization begins and charge builds up at some spot on the anode. The experimental data are checked against theoretical calculations of heat and mass balance at the anode. Figures 4; references 14: 12 Russian, 2 Western.

USSR

UDC 537.533.3

TRANSFORMATION OF BEAMS OF CHARGED PARTICLES WITH FINITE EMITTANCE BY MEANS OF SYSTEMS OF QUADRUPOLE LENSES WITH ABERRATION

Leningrad ZHURNAL TEKHNIKESKOY FIZIKI in Russian Vol 48, No 4, Apr 78 pp 823-826 manuscript received 11 Jul 77

SHPAK, YE. V., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Focusing of finite-emittance beams by means of lens systems with aberration is considered in the paraxial approximation on the basis of Liouville's theorem. The corollary of this theorem about the invariability of areas containing the representative points in momentum planes and in phase planes respectively does not apply here, because of the aberration, and the change of areas upon transformation is taken into account accordingly by defining elliptical contours in the projection plane. The method is illustrated by transformation of a beam with a stigmatic triplet of quadrupole lenses. A numerical solution for a system with specific parameter values has been obtained with the aid of a BESM-4 high-speed computer. The authors thank S. Ya. Yavor for unwavering interest and helpful discussion. Figures 2; references 6: 5 Russian, 1 Western.

USSR

UDC 535.554

NONLINEAR RAMSEY RESONANCE IN NUMBER OF EXCITED PARTICLES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 1(67), Jan 78 pp 176-179 manuscript received 13 May 77

DUBETSKIY, B. YA. and SEMIBALAMUT, V. M., Institute of Physics of Semiconductors, Siberian Department, Academy of Sciences USSR, Novosibirsk

[Abstract] When three spatially separated standing electromagnetic waves interact with a gas on a Doppler-broadened transition, an optical resonance arises with a width that is the reciprocal of the time of flight of the atoms between the beams. This resonance is analogous in its properties to Ramsey resonance in the rf band. The physical essence of this effect is that for the given field geometry there is a nonlinear process of coherent transfer of polarization between waves. In this paper a formula is derived for Ramsey resonance in number of excited particles in a beam of atoms with maxwellian velocity distribution when these atoms interact with three spatially separated standing waves. As compared with resonance



4  
in coefficient of absorption, resonance in number of excited atoms has the advantage that all atoms of the beam interact with the three waves. There is also a corresponding increase in the ratio of the homogeneous width of the transition to the Doppler width by a factor of  $\theta_0^{-1}$ , where  $\theta_0$  is the angular divergence of the beam. The authors consider gaussian distribution of field amplitude with respect to transverse coordinates, enabling direct comparison of theory with experiment. The weak-field case is analyzed. Numerical calculations are done on the amplitude and shape of the resonance. Conditions for observation of the effect are defined that are optimum with respect to field intensity. The authors thank V. P. Chebotayev and Ye. V. Baklanov for interest in the work and discussion. Figures 4, references 5: 3 Russian, 2 Western.

USSR

UDC 621.378.001

PROPAGATION OF HIGH-POWER LIGHT PULSES THROUGH A SEMICONDUCTOR WITH INTERBAND INTERACTION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 2, Feb 78 pp 359-370  
manuscript received 26 May 77

ALEKSANDROV, A. S., YELESIN, V. F., LISOVETS, YU. P., MIKHAYLOV, V. G., POLUEKTOV, I. A., and POPOV, YU. M., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A theoretical study is made of interband interaction of a semiconductor with light pulses of almost any amplitude and width, the magnitudes of these two parameters being limited by the condition of "slowness" only. Maxwell's field equation and the equation describing the variable material properties of the medium are both solved with the aid of the Hamiltonian for the system and the single-particle density matrix of quasi particles accounting, in the form of collision integrals, for scattering by phonons and by impurities as well as for radiative recombination and Coulomb interaction. A typical evolution of a light pulse during passage through a semiconductor has been calculated by numerical integration, and the results found to agree closely with available experimental data for  $\text{CdS}_{1-x}\text{Sex}$  compounds. Figures 2; references 15: 14 Russian, 1 Western.

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